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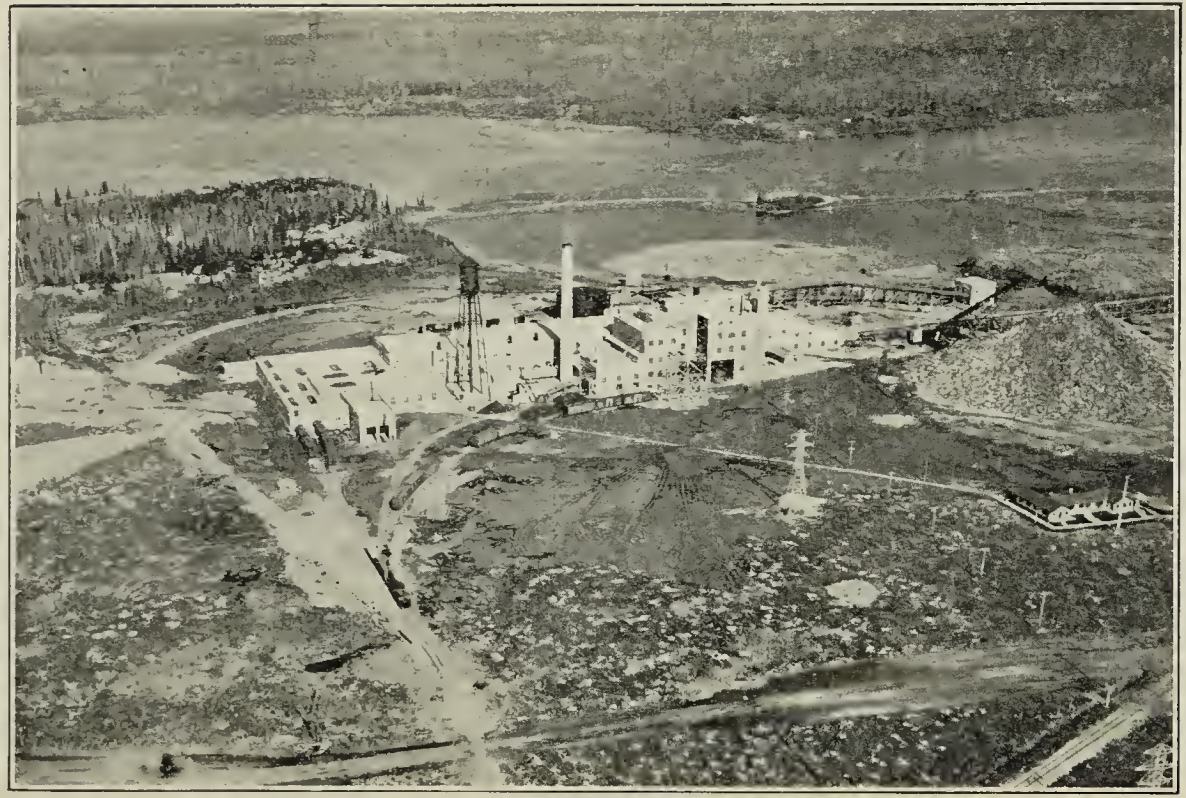
PULP AND PAPER-MAKING IN CANADA



The Manitoba Pulp and Paper Mill, Pine Falls, Manitoba.
Courtesy Royal Canadian Air Force.

PULP AND PAPER-MAKING IN CANADA

BY

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INTRODUCTION

The making of pulp and paper is the most important manufacturing industry in the Dominion of Canada. Nowhere else in the world are there such large pulp and paper mills, nor such large paper-making machines as are to be found in the provinces of Ontario and Quebec. All but two of the provinces of the Dominion have pulp and paper mills in operation, and most of the provinces possess enormous reserves of pulp wood available for the making of paper. The pulp wood areas are drained by streams possessing water power more than sufficient to operate the pulp and paper-making machines, and the surplus power is delivered to industrial centres far removed from the source of the hydro-electric development. Thus Montreal receives electric energy from the water power developed on the St. Maurice River, Toronto from the power developments on the Gatineau river north of the City of Ottawa, and Winnipeg from the falls and rapids of the Winnipeg River.

The Maritime provinces, British Columbia and even the prairie provinces share in the pulp and paper-making activities. The erection and operation of the mills, the building of dams and power plants, the cutting and transportation of the pulp wood, call

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for the employment of thousands of men and the purchasing of millions of dollars of supplies. The pulp and paper-making machines and the electrical machinery for the power plants are largely made in Canada. Hundreds of smaller industrial plants are supported in a large measure by the most important manufacturing activity in Canada, the making of Pulp and Paper.

J. W. S.

Winnipeg, June, 1929.

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PULP AND PAPER-MAKING IN CANADA

CHAPTER I

PAPER-MAKING MATERIALS

Paper consists essentially of an enormous number of fine fibres matted and interwoven so closely that a continuous surface is produced. If the torn edges of a piece of paper are examined some idea of the size of these fibres can be formed. The small hair-like structures projecting from the torn edges are the fibres out of which the sheet of paper has been made. A sheet of paper the size of the leaves of this book contains about two million fibres of natural length and five or six million fragments of fibres. These fibres and fragments of fibres, very short and fine, are woven together in the process of paper-making into a thin sheet of paper possessing considerable tensile strength and offering resistance to tearing. A smooth surface over which the pen will glide is given to the paper by filling up the spaces between the fibres with other materials. The fibres from which paper is made must first be extracted from the state in which nature provides them by one of the so-called pulping processes. Pulp obtained from

wood, straw, grass, bamboo, cotton or rags is mixed with a large volume of water, usually from one to two hundred parts of water to one of pulp. This water-suspension of fine fibres drops upon a screen through which the water falls leaving a mesh of fibres matted into a thin web—but that is another story, the full details of which will be found in the succeeding pages.

The making of paper is one of the oldest industries established by civilized man. Mummies, unwrapped after lying 4,000 years in the tombs of Egypt, yielded manuscripts on which the writing was still legible after forty centuries! The manuscripts were made from papyrus, a water plant cultivated by the Egyptians in the Delta of the Nile. For paper-making the stems of these plants were sliced into thin strips. These strips were laid side by side on a flat surface, across which another layer of strips was laid at right angles, and the mat, soaked in a little water from the river Nile, was pounded into pulp. The air-dried mat was next polished with a piece of ivory or a shell until the surface was smooth and even, after which about twenty of such prepared sheets were pasted end to end to form a roll.

When the Arabs sacked the city of Samarkand in 704 A.D., they found several establishments devoted to the making of paper. Cotton was the fibre used in the manufacture of paper by the citizens of Samarkand, and so impressed were the Arabs with the quality of this writing material that they adopted it throughout their whole dominions. Damascus

soon became as noted for the quality of its paper as for its swords and when the Moors crossed into Spain, the art of making Damascene paper was carried by them into Europe. From Spain paper-making spread to France and thence to Germany and England.

As cotton was not always avaliable in sufficient quantity to satisfy the paper-making industry, some time during the 14th century, pulp made from rags was substituted for cotton and the manufacturers were much surprised to find that it produced a better quality of paper. Rags produce a paper possessing qualities suitable for writing and book-making and until quite recent years all paper used for these two purposes was made of pulp prepared from rags.

The Arabs of Northern Africa discovered that the leaves of the Esparto grass or Spanish grass could be substituted for cotton. Soon this wild grass was cultivated and became an important agricultural product exported to the paper mills of Europe. All sorts of vegetable and animal fibres were then tried: straw, wood, waste fibres, linen, jute, bamboo, nettles, even weeds and any fibrous material produced in quantity near the paper mills. Some of these materials proved excellent substitutes for rags or cotton, while others were discarded as undesirable. Some were found to produce a pulp suitable for certain kinds of paper and not for others, while the cost of collecting and preparing the pulp from others made the use prohibitive.

Up to the year 1798 all paper was made by hand. In that year a Frenchman, Louis Robert, invented a machine which in a few years revolutionized the whole industry, making the production of paper in quantities comparatively cheap and easy and stimulating the development of new uses for the product. Improvements in the preparation of the pulp, in mechanical devices for the handling of materials, in the paper-making machines, and in all processes connected with the art of paper-making, have been very rapid in the last twenty-five years. The development of water power and electrical energy, the installation of chemical processes for preparing the pulp, and above all, the enormous demand of our modern civilization for paper, have stimulated a tremendous growth in the pulp and paper industry.

MATERIALS FOR PAPER-MAKING

As intimated in the preceding paragraphs, a wide variety of fibrous substances may be used in the making of paper. The seed hairs of cotton provide an excellent starting material, while the bast fibres of flax, jute, bamboo, esparto, straw and manila are the sources of the paper pulp in these plants. Pulp is obtained from the whole cells of the stems of poplar, pine, fir, spruce and hemlock. Asbestos paper, used for heat and electrical insulation, is made from a pulp prepared from the mineral fibres of the rock, in which form asbestos occurs in nature.

The essential constituent secured from plants for paper-making is *cellulose*. Wood is composed

principally of cellulose and it is the large proportion of this substance, its fibrous character, and the ease with which it can be secured in almost any degree of purity, which makes wood the most important source of paper-making material.

Almost all plants possess fibrous cellulose in their tissues but the proportion varies from species to species. Those plants in which the fibrous tissue is but a small proportion of the total, do not prove economical in the production of pulp. The cost of collecting, transporting and treating plant material containing a low percentage of cellulose, makes it impossible to use such materials in competition with wood where the percentage of cellulose is high. Nevertheless the modern demand for paper is putting such a strain upon the sources of supply, that study and research concerning new raw materials for paper-making are engaging the attention of research workers all over the world.

Sometimes, no doubt, the distance of sources of supply of the usual raw materials for paper-making makes it profitable to use some extraordinary materials but such usage will only affect the local demand and not that of the world's supply. Wood yields a desirable product,—long, strong fibres—and when the whole cost of collecting, transportation, handling and treatment, is taken into consideration the result will be found to favor the use of wood. The yield of pulp on a manufacturing scale from some of the materials already mentioned, is given in the following table:

Cotton	85	to	90	per cent.	dry pulp
Rags	70	"	80	"	"
Esparto grass	40	"	45	"	"
Straw	40	"	50	"	"
Wood (sulphite process)	40	"	50	"	"
Waste fibres, waste paper, bagging, etc.	75	"	90	"	"
Bamboo	40			"	"
Jute	50			"	"

The variation in the cellulose content of the Canadian woods used in the production of pulp and paper is given in the table below:

Hemlock	47.7	per	cent.	cellulose
Jack Pine	49.2	"	"	"
Black Spruce	50.6	"	"	"
Balsam	51.0	"	"	"
Red Spruce	51.8	"	"	"
White Spruce	56.5	"	"	"
Fir	57.0	"	"	"
Poplar	62.8	"	"	"

It will be observed that not all of the cellulose is recovered as pulp, there being a loss of up to ten per cent. in the processing operations required in its manufacture into paper.

Spruce is by far the most important wood in the manufacture of both mechanical and chemical pulp. When ground against the stones in the mechanical process of making *groundwood* pulp, the product is a mixture of fibres varying in length from "flour" to fibres as long as those produced by the sulphite process. The average length of groundwood fibres is, however, only one-quarter that of sulphite fibres. Spruce produces a white pulp and consequently no expensive bleaching process is required to decolorize it.

A fine stand of Pulp Wood untouched by fire.

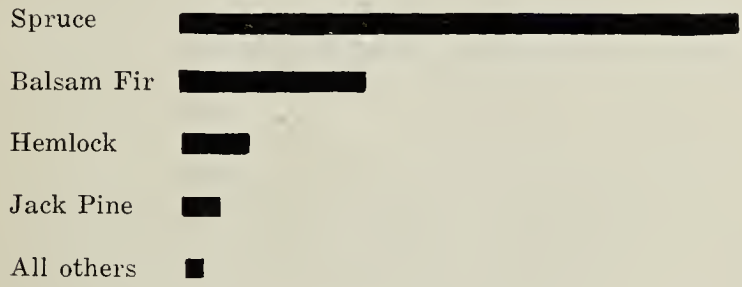
Abundant supplies of spruce wood occur in Canada and now that the forest resources of the United States are relatively depleted, those of Canada are becoming more important as a source of supply for the insatiable demand for paper. Although the visible supply of pulpwood in Canada appears inexhaustible, yet well regulated plans of forest conservation need to be carried out if this supply is to continue indefinitely, for in addition to the removal of the forests for pulpwood there must be added the destruction caused by fire and fungus.

Poplar and aspen are very largely used in making chemical pulp by the soda process. A soft, silky, pliable pulp, well suited for producing the highest grade of paper, is the result when the process is carefully carried out. Such paper is used in books, magazines, lithographs, maps, envelopes, writing papers, blotting papers, and the soft bulky papers required for special purposes. Poplar pulp is short fibred and lacks strength. For producing the papers mentioned above poplar pulp is mixed with the tougher-fibred pulp produced from rags.

Pine is not a very satisfactory wood for making pulp because of its pitch content. Not until the spruce, fir, hemlock, and balsam resources have been largely utilized will this wood be extensively used in the production of paper.

Hemlock and balsam are inferior to spruce for pulp-making purposes. Balsam carries a considerable pitch content causing trouble if the pulp is to be bleached, but as the fibres have good tearing

and cleavage qualities and are soft and flexible, this pulp can be used in the making of paper bags. Hemlock produces a reddish pulp somewhat inferior in quality to that of spruce.



Woods used in pulp production in Canada.

Straw and Esparto

Straw and esparto are treated by very similar processes in the making of pulp. In Europe esparto is an important starting material in paper-making, while in America it is rarely used. Straw is converted into pulp for use in newsprint and magazine papers or for the manufacture of strawboard. The method of treatment differs in the two cases since the straw pulp must be bleached before it is made up into paper.

Preparing Straw for Bleached Pulp

Rye, wheat, oat, and barley straw is the order of desirability of straw for paper-making. The collected straw is spread out on a table and carefully hand picked for the removal of all weeds, roots and other foreign material. A straw cutter then cuts the

stems into pieces two-fifths of an inch long and a gentle current of air provided by a fan separates the straw from all the nodes, grain, and sand it may contain. The nodes of the straw do not contain fibre and besides are very hard. They cannot be permitted to pass into the digesters as their presence absorbs a considerable amount of the soda uselessly, renders bleaching difficult, stains the pulp and reduces its value.

This special treatment required by straw, especially the hand labor connected with picking it over and the bulky nature of the material, renders the general use of straw less economical than that of wood. Straw for paper-making will not be a keen competitor with wood until the supply of the latter becomes more limited than at present.

The digesting of the cut straw in the soda digesters is similar to that carried out in the digesting of wood, and, together with the bleaching process, will be described in detail in a succeeding chapter.

STRAW-BOARD

For the making of straw-board or pasteboard, so extensively used for light box manufacture, the straw without any preliminary treatment is chopped up into short pieces, then blown along a wooden tube where a certain amount of separation of straw from the sand, dust, and grains takes place. The clean straw is then charged directly into a large iron tank where it is subjected to digestion with "milk" of lime for a period of about four hours and under a

steam pressure of 60 pounds per square inch. By this means the straw is softened and as the digester is rotated during the digesting process, the straw is reduced to a fine pulp and almost completely disintegrated. The digested pulp is removed from the boiler and the spent lye permitted to drain off, after which the pulp is washed with successive volumes of water until free from the lime liquor. The straw-pulp is now ready for compressing and drying into straw-board or pasteboard as it is commonly called.

Owing to the fact that straw is a cheap raw material, a by-product of grain production usually burned after threshing, many attempts have been made to extend its use in paper-making. It has been proposed to bale the straw and transport it to paper mills centrally located where plenty of water is available for pulp-making, but as already mentioned, such mills cannot as yet compete with the wood-pulp mills. Straw-board factories, however, are being built in some grain-producing areas with the expectation of supplying the local demand for pasteboard, building paper, and the coarse varieties of pulp required by certain special industries. Most, if not all, of such factories in Canada, however, are using groundwood pulp for making their products.

It may be of interest to present at this point the relative value of the straws usually used for making pulp, the cellulose content being taken as the criterion:

Rye straw	49.6	per	cent.	cellulose
Wheat straw	50.0	"	"	"
Oat straw	52.0	"	"	"

The yield of pulp is however largely influenced by the treatment meted out to the chopped straw in the digester. If the lye used is strong, and the digestion long continued, a considerable quantity of the cellulose is dissolved and washed out of the pulp.

BAMBOO

The British are particularly interested in the use of bamboo as a raw material for the development of pulp and paper-making. The British Isles possess no resources in raw materials for paper-making but British tropical possessions have an abundance of bamboo cane brakes. Early in this century R. W. Sindall carried out extensive researches on the production of pulp and paper from this source and as a result of his work bamboo paper mills have been erected in India, Burma, and in the Philippine Islands.

As with straw, the nodes of the bamboo are rejected when the stems are cut. Either the sulphite or the soda process may be used in reducing the cut cane to pulp.

Paper made from bamboo is excellent for book and writing purposes. An interesting point about bamboo is the fact, that, after cutting, it grows again very rapidly so that only about 16 square miles are required to supply a 100 ton mill indefinitely. This is in great contrast to a wood pulp mill which requires hundreds of square miles of forest to insure a twenty year continuance of production. After the timber is depleted, this mill must be moved to

another virgin tract. The chief reason bamboo is not being more extensively used in the production of paper lies in the distance separating the lands where it is indigenous from the world's great paper markets.

Rags

At one time practically all the paper used in Europe and America was made from rags. Now only the more special and expensive grades of writing paper are made from rag stock. Bank notes, bond certificates, legal documents and most papers where permanency and not expense is the object, are manufactured from pulp prepared from rags. It is quite inspiring to reflect on the fact that a cotton apron may end its days beneath a bank's stamp giving it a value of many thousands of dollars!

The rags, after collection, must be sorted, dusted, and all buttons and pins removed. Cotton rags must not be mixed with linen, hemp or wool. This sorting is best done by hand, and although the process is costly and dangerous to the health of the workers, it results in a better selection of stock for the preparation of the higher grades of paper.

The rags are next put through a "dusting" machine which removes most of the loose dirt; then they are cut into small pieces and boiled for several hours in lime, The boiling reduces the rags to pulp, which, after being washed and bleached with either chloride of lime or chlorine water, is ready for making paper.

BAGASSE

After the extraction of sugar from the sugar cane the pulp, known as *bagasse,* was formerly used as fuel in the furnaces of the sugar mill. Now, a large proportion of this pulp is utilized in making bagasse board, manufactured by treating the fibrous cane residue with a liquor prepared by mixing lime with low grade molasses, a by-product of the sugar mill.

CORN STALKS

Much research work is being done in an attempt to produce paper-making pulp from the cellulose of corn stalks. If this work is successful the making of paper from an otherwise waste product would be of very great economic value to the farmers of the corn belt.

WASTE PAPER

No doubt all of us have speculated on the possibility of collecting a large percentage of the paper each year and utilizing the recovered fibre in the preparation of fresh paper. Eighty per cent. of the paper manufactured becomes waste paper within four years and of this only about seven per cent. is again used in paper-making. As a rule recovered waste loses caste and can only be used in preparing a lower grade of paper. Waste paper must be repulped, cleaned, beaten, ground, and put through many of the processes it has already been through when first made into pulp, and as a result the cellu-

lose fibres are broken and shortened, producing a sheet of paper much weaker than the original.

Almost all waste paper can, however, be utilized in preparing some kind of wrapping, cover, blotting or building paper or pasteboard.

Old newspapers, magazines and books offer the further difficulty encountered in removing the ink. Printers ink is composed of finely divided carbon held in suspension in linseed oil. There is no known solvent for carbon and consequently the carbon ink must be removed from the paper mechanically after dissolving the oil binder. The de-inking process requires the use of soda ash solution for attacking the oil accompanied by some sort of mechanical stirring for removing the loosened particles of carbon.

Several varieties of machines are used for this de-inking process and one, the Winestock machine, produces a pulp almost as white and as long-fibred as the original paper.

CHAPTER II

VARIETIES OF PAPER

The first and only use for paper was for writing. For many centuries the art of paper-making was confined entirely to supplying writing paper and not until very recent years was the use of this material broadened into the manifold requirements of our modern civilization. There has come into the pulp and paper-making industry the same highly developed specialization that is characteristic of the old-established industries such as, for example, is observed in the modern iron and steel plant, and in the petroleum industry.

The different kinds of paper are made by using different kinds of raw material and varying the processes whereby the raw stock is reduced to pulp. The paper manufacturer produces paper for the particular purpose required. There are few raw materials that afford wider variations in properties, or that lend themselves to wider ranges of adaptation than does paper pulp. The plastic nature of pulp with its ability to mix with many other materials, to assume all degrees of hardness on drying and afterwards to take on a hard polish, lends itself to the production of articles as widely different in form as tubs and flowers.

Writing and Book Paper

The manufacture of writing and high grade printing papers is not only the oldest but is also one of the most important branches of the modern paper industry. Such a paper requires an even, uniformly closed sheet possessing a high finish with an even bulk and at the same time must be soft and strong. Specially prepared pulp from cotton and linen rags, and pulp prepared from wood by the sulphite and soda processes are suitable for this variety of paper. In addition to the pulp, from 10 to 15 per cent. of *loading* materials must be added to render the paper more absorbent and opaque, and to permit the ink to make a clear impression.

When the pulp alone is formed into a sheet or web the product is porous, like blotting paper. In order to permit the paper to take the ink in a direction normal to the surface of the paper and in no other, the loaded paper is *sized*. China clay or kaolin, talc, calcium sulphate and barium sulphate, are substances in common use as loading materials, while rosin acted upon by alum, starch, sodium silicate or water glass, gelatin, casein, and soap, are materials frequently used for surfacing or sizing the paper. The processes for surfacing paper are very numerous and varied. After the writing paper has been coated and dried, it is run through pressing or calendering machines which produce exactly the polished finish desired.

Machine-finished paper having undergone the ad-

ditional process of sizing and calendering to give it a high finish, is the paper most in use for the higher grade of illustrated magazines such as the National Geographic, Maclean's, and the Saturday Evening Post, also for trade catalogues, advertising literature and books. It is also used for writing pads, school exercise books, for lining and covering paper boxes and as wrapping paper for special purposes.

Writing paper is in most respects quite similar to book or magazine paper but in addition calls for watermarks, engravings and a special finish, the latter usually the one characterized as the *linen* finish. The linen finish is produced by placing alternate sheets of the best linen cloth and slightly moistened paper between sheets of heavy tin until a pack of tin, linen and paper about four inches thick is made. The pack is then run through heavy plate rolls and the paper receives the imprint of the linen.

Hand-made Paper

Small quantities of special papers such as stock certificates and bank notes, are made on hand machines. The specially prepared pulp, or "stock", is contained in a vat into which the workman dips a mould or wire-cloth. After the mould is lifted out, the water is permitted to drain off, and a layer of pulp covers the wire cloth. This layer having been pressed against a felt, the sheet of pulp is lifted off the wire and adheres to the felt. These felts are then stacked in piles and pressed to force out the water. The sheets are now removed from the felts

and hung up to dry. After drying, the sheets are dipped into the sizing solution—usually gelatin—and hung up on poles. Such papers are said to be loft-dried. After another drying, the sheets are calendered and plate-glazed, the latter process requiring the sheets to be pressed between heavy metal plates of copper or zinc.

The paper is embossed by passing it between rolls upon which designs or lettering have been cut.

The so-called *water marks* are produced by having designs or names made in a raised pattern on the wire-cloth mould. Less pulp lodges on the raised pattern and consequently the paper is thinner there.

Water marks may also be produced on machine-made paper by means of a light skeleton roll called a "dandy roll", covered with raised wires in the form of the desired pattern. Such a roll placed between the suction boxes, presses lightly against the still moist paper. The paper is thinned where the wire pattern presses and thus a design is produced.

Imitation water marks can be produced on the finished paper by subjecting it to pressure while in contact with plates upon which the design has been produced in relief. Very beautiful results are obtained by this method.

Wrapping-paper

Kraft wrapping paper is best adapted for wrapping heavy bundles. Although the Kraft is one of the newest paper-making processes, the use of its

product for wrapping purposes is rapidly displacing that of the old established processes. Combinations of ground wood pulp, sulphite pulp and waste paper, together with jute and various inferior stocks of paper pulp, have been used in the past to manufacture the various grades of wrapping paper but Kraft paper, because of the great strength, flexibility and compactness of the sheet produced, is now preferred either alone or in mixtures of Kraft with the varieties mentioned above.

Wrapping-papers for special purposes are prepared by sizing. Thus, butchers' paper must resist penetration by blood. Such paper is usually prepared from a mixture of unbleached sulphite and ground wood pulp specially sized and given what is known as the "blood test" before distribution.

Manila wrapping-paper, which was originally made from pulp prepared from rope waste, is now made from carefully selected sulphite pulp mixed with groundwood stock and colored to imitate genuine manila. A soft, flexible sheet is obtained by giving the finished paper a steam finish. Such a sheet when crumpled feels like silk.

Paper for wrapping cutlery and silverware is either tissue paper or wrapping-paper made from pulp after all the chemicals used in the processes have been carefully washed out. Compounds of sulphur or acids left in cutlery wrapping paper may cause tarnishing of the metal.

Tissue-paper

Tissue-papers are made from all varieties of paper stock or pulp. The thinness of the sheet is produced by using a pulp mixture containing very little pulp. Such papers are too thin to possess sufficient strength to be run on an ordinary paper machine, the web or mat of pulp always being supported on felt as it is carried from one roll to another. The thinness of the sheet shortens the drying and pressing processes so that a tissue-paper-making machine is much smaller and more compact than the ordinary paper machine. The crepe finish is imparted to tissue-paper by running it over corrugated iron rolls.

Paper towels require a combination of the qualities of tissue and blotting papers and the manufacture of such paper calls for a combination of the two processes.

Cigarette-paper

A good cigarette-paper must be free from aroma and quite neutral in flavor while the cigarette is burning. Rice straw was formerly used for making this paper, but pulp from rice straw does not possess sufficient strength for the modern cigarette-making machinery. Pure flax or linen fibre, hemp and ramie are the raw materials now used. Cotton fibre is sometimes used for the cheaper grades of cigarette-paper but owing to the lamp-wick odor imparted to the paper, such stock is never used for the higher grades. Chemical wood fibre does not possess suf-

ficient tensile strength for cigarette-paper-making machines.

When cigarettes were made by hand a wider choice of raw materials was afforded, and any pulp giving an odorless, tasteless, opaque paper could be used, but the cigarette-making machine has completely displaced the older hand process. Rice paper is commonly used for hand-rolled cigarettes.

Cigarette-paper is always bleached. It contains up to 25 per cent. filling material, usually magnesium or calcium carbonate, and is sized with starch or dextrine. There is no paper manufactured that requires more care in its preparation. All the processes are very carefully regulated as to chemicals employed, temperature, pressure and the time the paper is exposed to each process. After bleaching, the paper is thoroughly washed, drained and allowed to *ripen* for several months before going to the cigarette-making machine.

PAPER BAGS

A satisfactory paper bag should be strong, pliable, and not easily torn but should bend readily and possess considerable resistance to moisture. Both the raw materials and the methods of manufacture are chosen so as to give to bag paper these desirable properties. Paper does not become bag paper merely by running any sort of stock through the bag machine. Bags serve not only as containers but also as carriers and for the latter purpose, must be sufficiently strong and pliable to permit of being

twisted, folded and gathered into handles. When a paper bag containing three or four pounds of nails is carried home, the strain is greater than that applied under other circumstances to materials much stronger than paper.

Since a paper bag is subjected to strain from without and pressure from within the paper must be equally strong in all directions. This requires that in making the sheet the pulp must be distributed with the fibres running criss-cross in every direction (See text page 98). This eliminates any graining of the sheet which, if present, might cause splitting of the bag when folded. Bag paper is loaded and sized within narrow limits since the tendency to break on bending, or the property of brittleness, is increased with the quantity of sizing used.

Kraft pulp is the most satisfactory for making the strongest bags. As the severity of service decreases, larger proportions of sulphite and groundwood pulp may be employed in the making of paper for bags, until a mixture of groundwood pulp and sulphite pulp alone may be used for bags which are never subjected to much stress. Special papers are prepared for special bagging requirements.

Parchment Paper

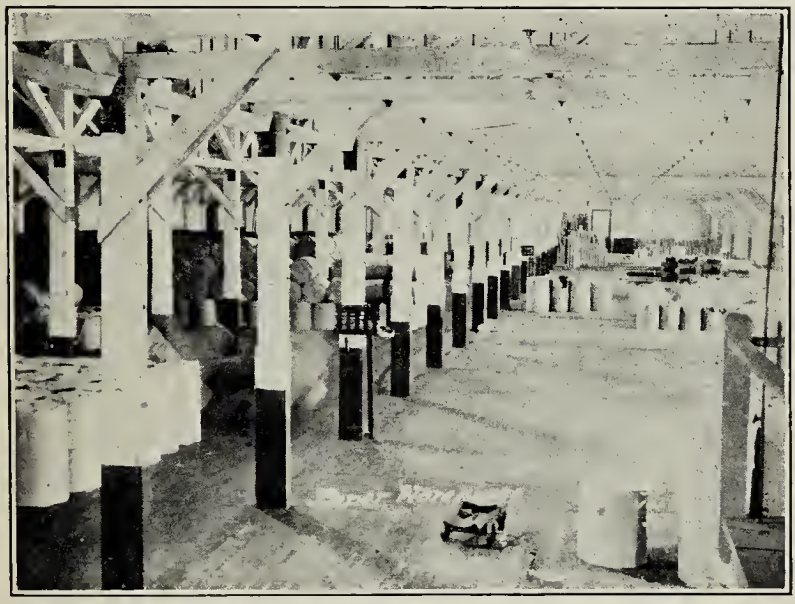
Diplomas, certificates, and degrees are inscribed on a paper possessing a skin-like surface. This surface is prepared by treating a good quality paper with either sulphuric acid or zinc chloride. The fibres on the surface are transformed into a jelly-

like mass hardening and forming a protective coating for the unattacked fibres below. Such paper is impervious to air and moisture and thus resembles parchment prepared from the skins of animals. Thus the term *parchment paper* is applied to this variety of paper.

NEWSPRINT

Eighty per cent. of the paper production of Canada is absorbed by the newspapers. This amounted to 2,381,102 tons in 1928, valued at $123,506,671, of which 1,934,889 tons were exported to the United States to supply the insatiable demand of the enormously large daily and Sunday editions of the American papers. The Saturday editions of the Canadian, and the Sunday editions of the United States newspapers are exceedingly bulky. They contain a heterogeneous mass of reading material of such wide variety as to include something of interest to all classes and ages. This material is collected into sections such as news, advertising, automotive, sport, church, financial, markets, movieland, literary, comics and magazine or short story sections and meets the popular demand in providing entertaining reading for filling in the hours of leisure over the week end. Such papers require much newsprint. The Sunday edition of one popular Chicago newspaper requires the cutting down of 75 acres of Canadian spruce. Much of this paper is manufactured in Canada, and the pulp and paper mills, the forest activities, and the manufacturing of machinery for

these mills offer employment for many thousands of men. At the present time, much raw material in the form of pulp wood and pulp is shipped to pulp and paper mills in the United States where it is transformed into newsprint. Year by year, however, a



Rolls of newsprint ready for shipment from Vancouver to Australia.
Courtesy, Pacific Mills Ltd., Ocean Falls, B.C.

larger proportion of newsprint is being manufactured in Canada and it is expected that in a few years the shipping out of pulp and pulp wood will be a thing of the past.

The export of newsprint paper is growing yearly and constitutes one of our most valuable sources of national revenue.

Most newsprint paper is made entirely of groundwood pulp but the better class of newspapers demand an admixture of up to 25 per cent. sulphite pulp. The pulp is never bleached and the process from grinding room to finished paper is an unbroken one. Time is an important element in manufacturing newsprint as the demand for increasingly larger tonnage grows. As a consequence the speed with which a paper machine is run and the width of the sheet has increased rapidly until the limit now is about 1,500 feet of paper per minute producing a sheet almost 300 inches wide—and the end is not yet. A modern newsprint paper machine is almost as much a marvel of ingenuity as is the huge printing-press into whose cavernous maw the paper passes.

Blotting and Filter-paper

Cotton fibre has the greatest capacity of any vegetable fibre for absorbing liquids. The best blotting papers are therefore made from cotton rags. The cheaper grades of blotting paper are made from groundwood pulp, while all degrees, from the highest grade to the lowest, may be prepared by varying the proportions of cotton pulp mixed with the mechanical wood pulp. Pulp for blotting paper is not loaded or sized.

Filter paper is very similar to blotting-paper. The best filter papers are made from cotton rags and in order to reduce the ash to a minimum, such papers are treated with hydrochloric and hydrofluoric acid.

These acids dissolve the mineral matter in the pulp and frequent washings with water give a product which on ignition leaves practically no ash whatsoever. Such paper is almost pure cellulose.

Swedish filter-paper is made porous by soaking the paper in water and permitting it to freeze. The small crystals of ice force apart the fibres, leaving the paper with a porous structure after it is thawed and dried.

Wall-paper

Wall-paper stock is almost identical with newsprint. The cheaper grades consist of groundwood pulp alone, while up to 20 per cent. sulphite stock is mixed into that used for the higher grades. To render the paper opaque and to give it a suitable surface, about ten per cent., by weight, of clay is added to the pulp. The surface is sized in order to render it capable of taking a good impression.

A good wall-paper must have softness combined with pliability, resistance to water, and a certain bulk.

There is no class of paper that requires more attention in the milling than does wall-paper. The quality of the paper is determined by the quality of the pulp proceeding from the groundwood mill, and consequently great care is exercised in this department to have the stock produced conform to the requirements of a good wall-paper. No matter how much care is exercised in subsequent operations, good wall-paper cannot be made from poor stock.

Since this is necessarily a comparatively cheap grade of paper, the machines must produce as much as possible in a given interval of time. We find wall-paper machines running almost as swiftly as their larger newsprint relatives.

Roofing and Building-paper

Any kind and grade of paper may expect to end its days in this home for old folks. Waste-paper of all sorts, low grade rags, old gunny sacks, discarded magazines, mail order catalogues, hobnob together in a tar paper roof.

Besides the ordinary building and roofing papers a large number of specialties containing asbestos, various chemicals, asphalt and sand have been developed. These papers are prepared either in rolls or as boards and are finding an increased use as insulating materials as well as for the ordinary uses to which such kinds of paper are put.

The special varieties of straw-board and paste-board were considered in the chapter describing the use of straw in paper-making.

CHAPTER III

CANADIAN FORESTS

The rapidly increasing demand for paper, especially newsprint, has turned the attention of the paper industry to the available forest areas of the world. The great cities of America demand an increasingly larger supply of paper year by year, and with a diminishing supply of suitable forest growth in the United States, the great forest resources of Canada are being tapped in order to keep pace with the market's demand. Enormous areas of timber land are being secured by the paper interests. New leases for the cutting of pulp wood are being granted by the Dominion and Provincial Governments, new pulp and paper mills are springing up across the continent from Halifax to Prince Rupert, and coincident with the mill-building operations has come the development of water power from the innumerable streams flowing down to the sea.

Not so many years ago lumbering and timbering operations and the manufacture of charcoal included all the industries connected with the northern forest areas. Then, as the demand for potash in soap-making called for more and more of this compound, whole forests in Europe and America were cut down

and burned in order to secure the potash obtained by leaching the ashes. This entailed an enormous loss of valuable timber and continued unchecked until the discovery of the rich deposits of potassium chloride at Stassfurt in Germany and in Alsace-Lorraine in France. Finally the preparation of caustic soda by the electrolysis of brine provided a cheap substitute for the more expensive potash, and the wanton destruction of the forests ceased. None of the forests of Canada were destroyed in the interests of cleanliness.

The railway development during the first decade of this century saw two new transcontinental lines completed across Canada, with numerous shorter lines criss-crossing the whole southern strip of the Dominion. These served to open up enormous areas of timber lands previously unavailable because of lack of transportation. When the demand for pulp and paper arose, transportation was immediately available whereby the product could be carried to market. Moreover, the new lines of communication, particularly east from Winnipeg, cut across the headwaters of the streams pouring into Hudson Bay, the Great Lakes, and the St. Lawrence. These streams possess water power, the cheapest form of energy available for useful work. The upper reaches of these streams, lakes, and lakelets, afford means for the transportation of the pulp wood to the mill. A trip east from Winnipeg across the waste of dark spruce lands is

broken every little distance by a stream, a mill, a water power plant, a settlement.

The forested area of Canada stretches almost continuously from Coast to Coast. In the east, the Great Lakes and the deforested areas of the agricultural lands form its southern boundary, while in the Middle West the prairies push the forests to the north of 53°. West of the Rockies the local rainfall determines the timber covered areas, while to the north the size of the trees gradually diminishes, the growth becomes stunted, and the forests finally disappear.

The Dominion of Canada supports three distinct types of forest growth which may be roughly divided into: (1) The Pacific Slope, west of the Rocky Mountains; (2) The Great Plains region, draining into the Arctic and Hudson Bay; and (3) The Great Lakes Basin, including the St. Lawrence and the Maritime Provinces.

The Pacific Slope

The numerous systems of mountains running parallel to the coast intercept the moisture-laden westerly winds from the Pacific, giving the maximum precipitation on the Coast Range, and what remains after crossing the interior plateau is precipitated on the lofty Selkirk and Rocky Mountain ranges, giving a second wet belt included largely in the Upper Columbia Valley. The annual precipitation on the Coast is from 40 to 120 inches, falling mostly during the fall and winter seasons. The Interior Dry Belt

on the plateau region has an annual precipitation of only 10 to 20 inches, while that in the Columbia Valley may range from 30 to 60 inches.

The greater part of the precipitation takes place outside the growing season and to this fact is attributed the preponderance of coniferous over deciduous trees on the Pacific Slope. Whatever the reason, coniferous tree growth is here the most luxuriant in Canada. Here occur the heaviest stands of timber, the largest individual trees and the most rapid rate of growth. These forests extend up the mountains from sea level to a height of over 4,000 feet in the south and under 3,000 in the north.

Douglas fir and red cedar constitute the principal species found on the Pacific Coast towards the south. Further north the fir is displaced by the hemlock and spruce. The Sitka spruce is the dominating tree on the Queen Charlotte Islands and the adjacent coast. At altitudes above 2,500 feet red cedar and hemlock, associated with white pine, are the important trees.

The Interior Dry Belt of British Columbia is an irregular, elongated strip lying east of the Coast Mountains, and largely contained in the plateau region stretching eastward to the Selkirk and Rocky Mountain ranges. At the lower altitudes yellow pine and several varieties of spruce are found, while at higher altitudes these are intermingled with valuable stands of Douglas fir. White pine, hemlock, larch, lowland fir, and cottonwood are found on the bench lands, but to the northward the only valuable

A stand of timber in British Columbia. These immense Douglas fir trees have not been injured by fire.

varieties are the Englemann spruce and the Alpine fir.

The Columbia Valley contains most of the varieties found on the coast and on the Dry Belt, the distribution being largely determined by the relative rainfall and the altitude. In the Rocky Mountains the Englemann spruce, the white spruce and, on burned-over areas, the lodge pole pine are the important stands of timber. The Douglas fir also occurs occasionally and extends in a few cases to the eastern slopes in Alberta.

THE FORESTS OF THE GREAT PLAINS

Eastward from the foothills of the Rocky Mountains to the glacierworn rocks of the Canadian Shield the whole northern portion of the great central plain is practically treeless so far as timber for lumbering or paper-making purposes is concerned. This prairie area extends northward from the international boundary for 200 to 400 miles. Isolated patches of poplar, white spruce, and jack pine are occasionally found in protected areas, but the agricultural and pastoral areas are practically continuous in an easterly and westerly direction for over 800 miles. On the north these areas are irregularly bounded by the great Northern Forest-belt extending from the foothills to Labrador. The dominant tree in this belt is the white spruce, the most important source of pulpwood in central and eastern Canada. Balsam, poplar, jack pine, tamarack, and birch are other important varieties occurring in this great Northern

Forest. Unfortunately forest fires have recently destroyed enormous areas of this forest land and so far these have not been reforested to any great extent; in fact many of them have been burned over more than once.

Along its northern margin the trees of this forest belt gradually become stunted in growth and merge into the treeless Arctic tundras. Along the streams flowing into the Arctic Ocean dwarfed specimens of white and black spruce, tamarack and larch extend almost to the sea, while further northwards only the willow is found. The northern limit of tree growth is practically defined by a line drawn from the mouth of the Mackenzie River to the mouth of the Churchill River on Hudson Bay and across the Labrador peninsula along the 58th parallel of latitude.

The Eastern Forests

The great Northern Forest extends southwards in central and eastern Canada until it reaches the Great Lakes or the deforested agricultural areas of Ontario and Quebec. The character of the tree growth gradually changes from the Height of Land to the southern limit of the forested area. White pine and Norway pine on the lighter soils, with spruce and hemlock on the heavier, and tamarack, black spruce and cedar occupying the swamps, form the more important stands of timber. Hardwoods, chiefly maple and yellow birch, occupy the northern ridges, while to the southward other valuable varieties of hardwood occur.

The exclusive cutting of white and red pine, practised until the era of pulpwood cutting was established, has resulted in the natural reforestation of large areas with spruce, balsam, jack pine, poplar and the hardwoods. Jack pine in particular is to be found established on burned-over lands where the soil is sandy.

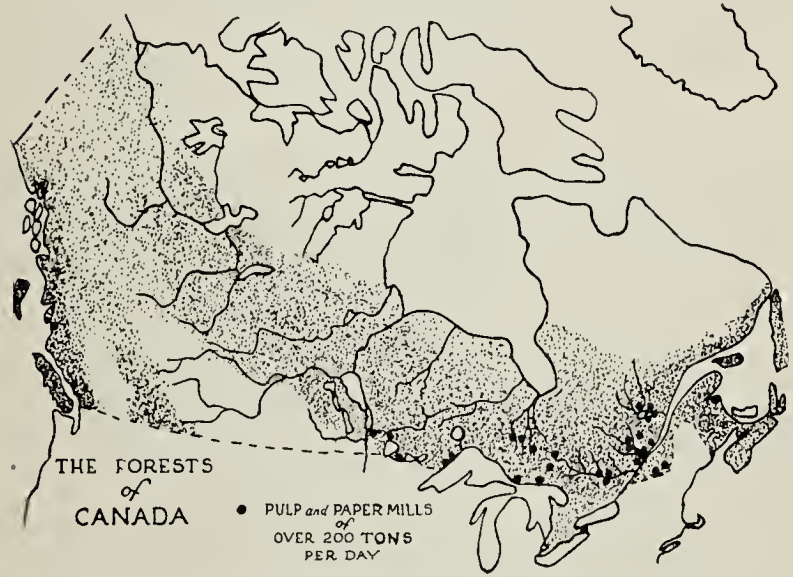
This forested area extends eastward through New Brunswick and Nova Scotia providing very valuable stands of timber, both of the soft woods suitable for pulp and paper-making and of the more valuable hardwoods. Red spruce, white spruce, hemlock, white pine, birch, maple, and beech are the most important varieties.

Forest Resources

Land in Canada suitable for agriculture, including pastoral land, is estimated at 560,000 square miles, of which less than 100,000 is yet under cultivation. The area covered by existing forests approximates 1,280,000 square miles, only 40 per cent. of which carries merchantable timber (6 inches in diameter) and only 20 per cent. carries saw timber (10 inches in diameter). The balance of the timbered area carries young timber, growing up after deforestation or coming up after fire. One-quarter of the marketable timber is at present inaccessible, so that two-thirds of our forested area is either too small or too expensive to be operated profitably.

Young stands as they reach maturity (about 30 years for white spruce) increase the area of acces-

sible timber while forest fires, wind falls, fungus and insect damage, and commercial operations tend to reduce the area. One-fifth of the total forested area in Canada has been set aside as a forest reserve or for park purposes.



The forested areas of Canada showing the location of the larger pulp and paper mills.

Little reliable information exists as regards the actual quantity of timber on the forested areas of Canada. Comprehensive forest surveys have been made only by the provinces of British Columbia and Nova Scotia while for all other provinces only rough approximate information is available. The table below indicates that British Columbia possesses the greater part of the saw material and the eastern and prairie

provinces the most of the hardwood. The prairie provinces possess more than half as much pulp wood as the eastern provinces and the hardwood is distributed about equally between the two. The possession of these valuable forest reserves by the prairie provinces is not generally appreciated.

ESTIMATED STAND OF MERCHANTABLE TIMBER IN CANADA

	Soft Wood		Hard Wood	
	Saw-Material 1000 ft. B.M.	Pulp Wood 1000 cords	Saw-Material 1000 ft. B.M.	Pulp Wood 1000 cords
Eastern Provinces ...	76,101,000	552,210;	32,134,500	209,815
Prairie Provinces ...	17,985,000	272,010;	9,305,000	196,010
British Columbia ...	345,762,000	47,500;	788,000	2,160
Total	439,848,000	871,720;	42,227,500	407,985

CONTROL OF FOREST RESOURCES

Fairly strict regulations are now established in relation to the removal of timber, the size to be cut, and the disposal of debris. Royalties in the form of stumpage taxes or per cordage measurements accrue to the province or to the Dominion, and these are adjusted at definite time intervals to suit the changing price of the product. There are no regulations in regard to the disposal of timber on privately owned land but, with the exception of Nova Scotia, the export of raw or unmanufactured timber cut on crown lands is prohibited. This requirement provides for all the labor connected with lumbering and sawmill operations being carried out in Canada, and thus ensures the Dominion and the provinces the maximum advantage from the disposition of these resources.

The disposition of pulpwood is not, as yet, quite as satisfactory as that of saw timber. Manufacture of all pulp wood into paper in Canada is not required, although the practice is to grant individual pulp wood agreements on the basis of the licensee erecting a paper mill within the province in which the timber is cut. Pulp wood cut on privately owned lands may be exported.

CHAPTER IV

FOREST DESTRUCTION AND FIRE PATROL

Until very recent years little attention was paid to the destruction of our forest reserves. The lack of realization of loss was due to two contributory causes, first, the resistance offered by the forests to the bringing into cultivation of heavily timbered land, and second, a lack of demand for the timber. The agricultural settlement of the whole of eastern Canada required the clearing of the land from a very heavy growth of timber, frequently of hard woods. The labor entailed was enormous, and it required two generations or more to clear even the small farms of Ontario, Quebec, New Brunswick and Nova Scotia. There was little market for the timber and it was customary to burn it where it lay. "Burning the fallow" was the term applied to this clearing process. After the burning was completed the first and succeeding crops were planted by hand amongst the stumps, harrowed in by hand or by a small "drag" pulled by one horse, and the harvest removed by the scythe or sickle. Not for years did the stumps rot sufficiently to enable their easy removal from the field. Except for the personal danger entailed and the threat of destruction to crops and

buildings, fire was considered the particular friend of the pioneer in clearing the land for cultivation. A second fire following the first made a fairly complete clearing.

The utility of fire in clearing the forested lands for agricultural purposes generated a friendly feeling towards this element and it was not realized that fire out of control, in areas unsuitable for agriculture, wreaked irreparable destruction on one of our most important natural resources. Then, as the timber adjacent to the agricultural areas of the east was removed, and a growing foreign demand made even the then inaccessible limits desirable, it was realized that the recurrence of fires in areas unsuitable for agriculture was undesirable. Public sentiment, however, changed slowly. Ignorant of the widespread damage already done, governments were tardy in enacting preventive measures, and destruction has continued up to the present.

No accurate estimate of the damage done to our forests has ever been made, but an approximate estimate shows that about 60 per cent. of the original forest has been burned, 13 per cent. has been cut for use, and only 27 per cent. remains. Even during the last six years one-third as much merchantable timber has been destroyed by fire as has fallen to the axe and saw.

Historic Fires

The Miramichi fire in 1825 burned along the heavily wooded valley of the Miramichi River of New

Brunswick. The season had been hot and dry, the forests were parched and the moss, muskegs, and pine needles were as dry as tinder. The streams became dry, offering practically no resistance to the passage of the fire. A belt of heavily timbered forest land 80 miles long and 25 miles wide was swept by fire, almost every living thing perishing in the flames. One hundred and sixty people perished, 1,000 head of stock were killed and the towns of Newcastle, Chatham, and Douglastown destroyed.

In 1845 the region immediately west of Lake Superior sustained a very dry, hot summer. Fire swept the area clean so that even to this day many of the hills and slopes remain bare of trees. A few years later the height of land from Lake Temiskaming to Michipocoten was burned, and in 1871 the chain of desolation was made complete by the burning of over 2,000 square miles along the north shore of Lake Superior. About the same time the greater part of Saguenay and Lake St. John district in Quebec was swept by fire and practically all the forest destroyed. In 1891 and again in 1896, the Algoma district suffered a fire loss of over 2,000 square miles of timber. Smaller fires, but numerous, have destroyed very large areas of forest in the upper Ottawa Valley and in the country lying between this and the Lake St. John district.

On July 11th, 1911, a number of isolated fires in the Porcupine mining district of Northern Ontario combined, and rapidly swept the surrounding country. Seventy-two people were unable to get out

of the path of the flames and were smothered or burned to death. A second fire in 1916 again swept this district and 224 people perished, while a third visitation in 1922 destroyed the town of Haileybury and other villages, caused a loss in life of 40 people,

Forest fire in Central British Columbia.
Large areas of merchantable timber were destroyed by this fire.

rendered over 4,000 homeless, and destroyed property of more than $3,000,000 in value.

In 1908 a very serious forest fire swept down on Fernie, B.C., destroying the town and outlying settlements. Twenty-five people lost their lives, 6,000 were rendered homeless and property, other than timber, to the value of more than $5,000,000, was destroyed. Most of the timbered valleys in the dry

belt of British Columbia and in the Rockies have been ravaged by numerous fires while much of the timber area in the Northern Forest belt has been at one time or another swept by fire.

FIRE LOSSES

As already mentioned, 60 per cent. of the original forest in Canada has been destroyed by fire. In addition, much of this area has been burned over a second and third time destroying the young growth, nature's effort at replacing the loss. When it is considered that from 30 to 100 years or longer is required to replace this loss and that the new growth is seldom of as valuable varieties of trees as the original forest, the almost irreparable loss already sustained by our timber reserves from this one source alone, is appalling.

The burnt over areas of spruce and balsam in the Northern Forest belt of the prairie provinces is replaced by a second growth of the less valuable poplar and Jack pine. Further eastward poplar and white birch replace the burned timber, while spruce, balsam, and jack pine are coming in as second growth on the extensive cut-over, but not burned, areas of the original white and red pines.

The present annual loss by fire is estimated at 723,250 acres, or 31 townships, of merchantable original forest. Moreover, more than 35 townships of young growth and 25 townships of cut-over land are annually burned over, these last two losses representing the increment of about 30 years. These

annual losses are at present greater than the natural increment by new growth, required to replace the annual cut of merchantable timber. Unless fire protective measures are immediately made more effective, it will be a matter of a comparatively short time until the capital loss on our forest reserves will seriously affect the lumbering, pulp wood and paper industry.

Origin of Fires

The question naturally arises as to why the forests have not been completely destroyed by fire long ago. The answer lies in the fact that the fire losses have accompanied settlement. More than 95 per cent. of the fires of known origin are due to human carelessness, and therefore preventable. Campers, settlers and railways are responsible for most of the fires whose origin has been investigated and few, except in eastern British Columbia, have been found to start from lightning, the usual scapegoat.

Forest Fire Protection

The Dominion Government and the Provincial Governments are alive to the importance of fire prevention. Under the Forestry Branch, in each of these governments, there is found a well organized fire-protection staff co-operating with each other and with similar staffs connected with the railways, pulp and paper companies and the lumber companies. A Dominion Law requires all railway companies to provide adequate fire patrol along their rights-of-way.

The simplest form of patrol is carried on by men usually travelling in pairs, on foot, on horseback, or in canoes. Since the institution of fire patrols several measures have been adopted whereby the efficiency of their work has been very greatly increased. Strategic portages have been cleared, roads have been extended and trails prepared, telephone lines have been built through the forest, and lookout towers and stations established on dominating eminences. The use of aircraft for detecting incipient fires, and for carrying men and supplies to fires already started, has proved their worth over and over again. The innumerable lakes and lakelets dotting the great Canadian shield afford a ready landing place for the hydroplanes of the forest air service. Many stations established in the forest area carry supplies for the air force, and this branch of the forest protective service, with its ready mobility and rapid transit, is proving to be a most efficient means of fighting fires, especially before they have assumed large dimensions.

The natural resources of the three prairie provinces are under Dominion Government control and the protection of the timber on the crown lands in those three provinces, (also along the railway belt in British Columbia), devolves upon the Dominion Forest Service of the Department of the Interior, Ottawa. This service co-operates with the Royal Canadian Air Force in patrolling the more important timbered areas in the middle west. The R.C.A.F. supplies the aircraft, controls the personnel of the

flying force and selects the air stations, while the D.F.S. provides the fire fighters and the fire fighting apparatus, and directs patrol and fire fighting operations in general .

Use is made of the daily reports from the meteorological station, Winnipeg. When this station reports low humidity, especially during a dry season, the danger of fire outbreaks is known to be greater, and the light air planes or hydroplanes are ordered on patrol. High humidity, with rainfall, lessens the fire hazard and little or no patrol service will be required until the weather changes.

Lookout stations in relatively flat areas are of little use, but in hilly or mountainous country a lookout on a high hill is invaluable in detecting and locating fires.

Hydroplane forest patrol for protection against fire losses has practically displaced all other means in large areas in Ontario and Manitoba. Light scouting planes equipped with wireless are kept at several stations and fly over the forested area along definite predetermined air lanes. The altitude of the plane makes it possible not only to detect fires and to estimate their size, but also to determine the best means of extinguishing them. The wireless operator on the scouting plane reports to the station the location and character of the fire, and a second larger hydroplane carrying, if necessary, a portable gasolene engine and hundreds of feet of rubber hose flies immediately to the fire. This hydroplane flies back and forth between the scene of the fire and the

ranger station carrying men, supplies and equipment. The fire-fighting equipment includes such familiar tools as shovels, spades, axes, and hoes, while less familiar but exceedingly useful are the water packs which are carried on the back and operated by a hand syringe or squirt.

The scouting plane takes no part in the fire fighting or in transporting fire-fighting apparatus but remains in the air reporting the progress of the fire to the station or continuing its work of observation over other sections of the forest area. Scouting planes keep in touch with the base every fifteen minutes by radio and carry homing pigeons for emergency use. If a fire assumes large proportions, the ranger service impresses miners, prospectors or any other able-bodied men within a reasonable distance of the fire. These are transported by hydroplane to the nearest points of attack and are kept provided with fire-fighting apparatus and supplies so long as their services are required. After the fire is under control, they are returned quickly and expeditiously by the same means of transportation.

Since the inauguration of this method of fire patrol few large fires have occurred in the areas under observation. Many fires are located shortly after they break out and are brought under control in a few hours. Larger fires, under the direction of the observer in the hydroplane, are fought along lines most likely to result in bringing them under control. The observer in the air can locate the streams and lakes and thinly timbered areas along which the fire

fighters can best hope to hold the flames from spreading.

At present all the wooded area east and north of Lake Winnipeg and as far west as The Pas is patrol-

Fire in Pulp Wood Forests of Manitoba.
Aerial patrol by hydroplane readily locates such fires, and men and fire-fighting apparatus can easily be transported to the scene.

led by hydroplanes. The wooded slopes of the foothills of the Rockies are also under aerial patrol from the High River, Alberta, station but owing to the lack of lakes and suitable rivers hydroplanes are not used. Very few landing places are available in this rough, wooded country and the aerial service is only of use in locating and describing the fires. Other much slower means of transportation have to be used

in getting to the fire and as a consequence the control of fire is not nearly so efficient as on the Great Central Plain.

The headquarters station for aerial patrol in Manitoba is located at Lac du Bonnet on the Winnipeg River. Starting with but two planes in 1919 the patrol is now served with fourteen of the very best hydroplanes obtainable.

Wherever the conditions permit, automobiles, boats and railway speeders afford rapid means of transport. Cabins for the accommodation of patrolmen and supplies for fire-fighting are maintained at strategic points; while portable forest fire pumps are provided wherever their use is possible. The establishment of fire lanes and cleared fire-guards through the forest, and around fire-hazards, helps to confine serious outbreaks within definite limits.

Several serious fires have originated in the careless burning of fallows and brush by settlers during the dangerous dry periods. The establishment of close seasons for brush burning has proved efficient in removing this fire menace. Quebec and New Brunswick have enacted laws regulating and restricting travel in the woods during the fire season and these, strictly enforced, have been of great value as preventive measures.

Public interest in forest protection has been thoroughly aroused through the medium of the public schools, the railway companies and the press. The apathy which in the past resulted, through lack of

preventive and protective measures in the destruction of so large a portion of our forest domain is not likely to occur again. One of the saddest sights in Canada is the bare, blackened trees of the fire-swept forests standing as mute evidence of the carelessness of man in not protecting one of his great natural resources.

Losses Due to Insects and Fungi

More than 100,000,000 cords of spruce and balsam pulp wood are estimated to have been destroyed by the spruce bud worm in Quebec during the period 1912 to 1923. In New Brunswick the loss was placed at 15,000,000 cords for the same period and smaller losses were sustained in eastern Ontario. This infestation has recently appeared in British Columbia and in Manitoba but has not as yet attacked the great coniferous forests of northern Ontario. There are other insects destructive to our forests, but none entailed such a heavy drain as this one. The active stage of the spruce bud-worm is now believed to be over.

Fungous or rot diseases are more insidious, though less spectacular, in their attacks upon forest growth than are those of insects, but the losses sustained are probably just as great. Trees damaged by fire, and the poplar and birch of the second growth on fire-swept and cut-over areas, are particularly susceptible to fungous attack. Poplar and white birch rarely reach over ten inches in diameter without considerable decay.

Few attempts have been made to combat the insect-fungous attacks upon our forests, largely because of the difficulty in controlling either, and the expensive nature of any sort of preventive or curative measures. The relatively small size of the timber in the eastern and central forests of Canada would make the application of any sort of protection practically prohibitive, but in the tall timbers of the Pacific Coast where one tree contains as much wood as a hundred of the eastern trees the application of curative measures ought to be economically practicable. During the summer of 1928 a considerable area of coniferous timber in the Bras d'Or region of Cape Breton was dusted with powdered calcium arsenate in an effort to check the ravages of the spruce bud-worm. The dusting was accomplished by air plane in a manner similar to that employed for checking the spread of stem rust on wheat by dusting the fields with sulphur. The calcium arsenate adhering to the needles and buds of the spruce poisons the feeding larvae of the bud-worm moth.

CHAPTER V

PROCESSES FOR PRODUCING PULP

As the several processes by which wood, rags, and other material are converted into pulp must be referred to frequently throughout the book, a short description of these processes will prove of advantage to the reader in following the various treatments to which the raw materials are subjected. Since wood is, at the present time, the raw material most used in the paper industry, the processes by which it is converted into pulp will be first described.

Wood is made into pulp suitable for manufacturing paper by two distinct methods. The first produces pulp by *mechanical* means, the second by *chemical* means. Pulp produced by the first process is known as mechanical or ground wood pulp, and that produced by the second is designated chemical pulp. Chemical pulp is produced from wood by the sulphite, the soda, and the sulphate or Kraft processes.

Mechanical Pulp

Ground wood or mechanical pulp is manufactured by grinding the peeled or barked wood into a fibrous condition without any preliminary chemical treat-

ment other than a slight steaming to which some varieties of wood are subjected. The groundwood process is exceedingly simple as it merely involves the wet grinding of sticks of wood. It is usually carried out by forcing the wood against a rotating stone cylinder, possessing a roughened surface and constantly wetted by a stream of water. The tearing of the fibres produces a pulp of inferior quality in respect to strength but, when cheapness of product rather than high quality, is the determining factor, groundwood pulp serves for many kinds of papers. When judiciously mixed with the longer fibred chemical pulp its usefulness is much extended. Newsprint, bag, and wrapping papers, are largely made from mechanical pulp.

A longer fibred and tougher paper is produced from groundwood pulp if the wood is subjected to a preliminary steaming. This process softens the wood and, on grinding, the fibres are not torn and broken to the same extent as with the unsteamed wood. The steaming process, however, brings out the resins which on exposure to the air oxidize and give an objectionable brownish color to the pulp. This limits the use of this kind of pulp to the making of wrapping paper, pasteboard and such like products where color is not objectionable.

Sulphite Pulp

A water solution of sulphur dioxide, the gas obtained by burning sulphur in air, will dissolve and extract much of the lignin and resinous material

found in wood. If this acid liquor is first permitted to react with limestone, a soluble salt known as calcium bi-sulphite is produced. This solution mixed with the acid is more efficient than the acid solution alone in removing from the wood the substances

Sulphite Towers (on right), and the Digester Building of the Hawkesbury Pulp and Paper Mill.
Courtesy Canadian International Paper Co.

other than cellulose. Moreover, it does not injure the pulp as much as does the acid liquor alone so that almost all sulphite mills now use this latter solution.

The rossed wood (wood from which the bark has been removed) is chipped in a chipping machine and the chips are cooked for several hours in a large

steam-heated tank filled with the sulphite solution. After washing, a white, long fibred pulp is produced which is well adapted for making the higher grades of paper. This pulp must be bleached with chloride of lime or chlorine water when the very best grades of paper are desired. Sulphite pulp will not turn yellow with time, as is the case even with the very best groundwood pulp.

Sulphite pulp costs more than groundwood pulp, as much labor and power is used in handling the material and the capital expenditure in acid plant and digester is high. The machinery also is expensive and the acid nature of the liquor adds greatly to the repair bills on the metal parts of the plant.

With the mechanical process there is little direct loss of fibre in the conversion of wood to pulp, but in the sulphite process there is a considerable loss of fibre due to the solvent action of the acid liquor on the cellulose. The almost complete disappearance of lignin, resins, pentosans and constituents other than cellulose into the waste liquor, is characteristic of the sulphite process. Thirty cords of rossed wood will produce approximately 34 tons of groundwood pulp; this same amount of wood chipped and charged into a digester will yield only from 15 to 16 tons of sulphite pulp, the best possible yield with spruce wood being about 47 per cent., by weight. It is, of course, this removal of the constituents other than cellulose fibres that makes the sulphite treatment of wood so successful in producing a desirable pulp.

Soda Pulp

Caustic soda dissolved in water is the digesting agent in the soda process for producing pulp. Wood and other fibres when digested with hot soda solution have all the non-fibrous constituents dissolved leaving pure cellulose in an insoluble condition. After washing and bleaching, a pulp is produced that posesses a soft texture and a bulkiness, essential for paper which is to be used in manufacturing books, magazines, and writing paper.

The soda process is used in preparing pulp from such raw materials as poplar wood, all of the soft woods used for making pulp, straw, bamboo, and rags. In fact, it is probably the most widely used pulp-producing chemical process.

Sulphate or Kraft Process

Long fibred resinous and non-resinous woods may be digested with a mixture of sodium sulphate, caustic soda and sodium sulphide, the latter chemical really being the active ingredient in rendering the undesirable compounds in the wood soluble. The sulphate process is less injurious to the fibres than is the sulphite process, and consequently produces a stronger, tougher pulp from the same variety of wood. Certain kinds of wood, such as those high in resin, that cannot be utilized for pulp-making by the sulphite process, are readily transformed into desirable pulp by the Kraft or sulphate process.

Kraft pulp is brownish in color and is never

bleached because of the excessive cost connected with the bleaching operation. Owing to its toughness and strength this kind of pulp finds its greatest use in the manufacture of wrapping-paper and bags.

The term Kraft comes from the German word for strength, which is the chief characteristic of sulphate pulp.

The processes briefly described above are those in general use in the pulp-making industry. Besides these main branches of pulp manufacture there are special modifications required by the individual characteristics of the raw material. The detail in the treatment of straw, wood, rags, esparto, bagasse, cotton linters, bamboo, etc., is determined by the structure peculiar to each.

Bleaching Pulp

Wood pulp, regardless of the process by which it is made, must be bleached if it is to be used in any of the finer grades of light colored paper. Not all of the lignin or incrusting matter ordinarily associated with cellulose, is removed by the sulphite or soda process, and since certain colored bodies of complex, chemical composition are included with the lignin, these remain in the chemically prepared pulp. Other colored compounds are produced in the digesting process, so that, in order to obtain a white pulp, it is necessary to bleach the colored compounds by some chemical process.

The commercial bleaching agent is bleaching powder, a compound formed by passing chlorine gas

over hydrate of lime. This compound, in the presence of water, gives up chlorine, which in turn decomposes the water, freeing oxygen, which decolorizes the colored compounds in the pulp.

Chlorine gas, provided as liquid chlorine in steel cylinders, is rapidly replacing bleaching powder as a bleaching agent. Liquid chlorine is much more convenient to handle, obviates all uncertainty as to the making up of bleaching liquors, and permits a more certain control of the bleaching process.

Various types of bleaching apparatus are employed for bringing the pulp in contact with the bleaching liquor but the process is essentially the same in all. Since most chemical reactions double their speed for every 10° Centigrade rise in temperature, the time required for bleaching is reduced by heating the contents of the bleaching tank with steam.

Many paper mills prepare their own bleach by electrolyzing a solution of sodium chloride. Chlorine gas is evolved at the anode while caustic soda and hydrogen are formed at the cathode.* The caustic soda may be recovered by evaporation and sold, the hydrogen, however, is usually permitted to escape. Some plants permit the mixing of the chlorine and

*When a direct current is passed through a solution which will conduct electricity, the electrode at which the negative electricity leaves the solution is known as the anode while the electrode at which the negative electricity returns to the solution is known as the cathode. Hydrogen gas is evolved and most metals are plated out on the cathode while oxygen and chlorine gases are evolved on the anode. If the anode is a metal it may dissolve and go into solution under the influence of the electric current.

caustic soda in the cell, thus producing sodium hypochlorite liquor which is used for bleaching the pulp. Where water power is available, the manufacturing of their own bleach is a very profitable proposition for the paper mills.

Blueing

A small amount of blue, (ultramarine or some other blue) is frequently used to counteract the yellow color of pulp. Newsprint pulp is usually so treated, and sometimes imperfectly bleached pulp is given the blueing treatment.

CHAPTER VI

A MODERN PULP AND PAPER MILL

Location and Wood Supply

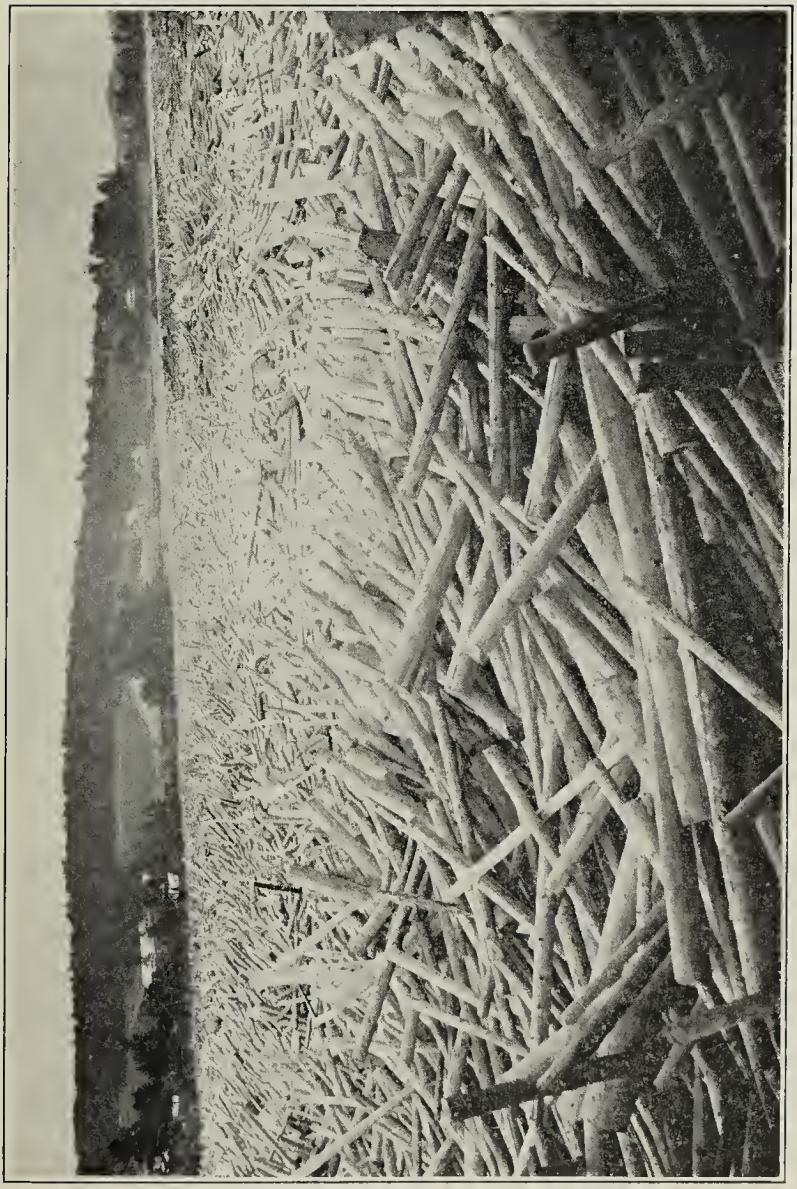
The location of a modern pulp and paper mill is determined by the source of raw material in relation to water power. The mill must not be far removed from timber limits or the cost of haulage will be too great. Enormous quantities of water are required in the various manufacturing processes in the mill, and much power is used in operating the heavy mill machinery. An ideal location for a mill is beside a waterfall, on a stream flowing through the timber limit. Such an ideal location is frequently found, and most mills in Canada are operated either directly from water power or by electricity generated from water power on the stream upon which the mill is built. Railway transportation is also practically essential for the rapid conveyance of the pulp and paper to market.

Since pulpwood is relatively small as compared with saw timber, it is easier to handle and consequently can be removed from more difficult locations. There is little pulpwood in central and eastern Canada that will not eventually be made available for

the manufacture of paper. Where possible, use is made of the streams for carrying the wood to the mill, but in addition much is transported by sleighs directly to the mill, or to the streams leading to the mill. The railways also transport large quantities

Transporting Pulp Wood to the Pulp Mill.

of pulpwood. This makes it possible to utilize pulpwood from small areas where there is not sufficient wood to warrant the building of a mill. As an example, the Pine Falls mill on the Winnipeg River is supplied entirely with pulpwood cut by private parties. Train loads of pulpwood are shipped to the Pine Falls, the Kenora and the Fort Frances



A Pulp Wood Jam on a River in Quebec.

mills from points in northwestern Manitoba as far removed as Hudson Bay Junction, Winnipegosis, and the Inter-lake region. The development of the pulp and paper industry has greatly assisted the seasonal labor problem throughout Canada, since it provides work during the winter months for teams and men otherwise idle, until farming operations begin again in the spring.

Much pulpwood is supplied to the pulp mills by the pioneer settlers along the transcontinental lines in Northern Ontario and Quebec. Heavily wooded farms are being cleared by the industrious French Canadians who instead of "burning the fallow" as their forebears were accustomed to do in Old Quebec, now haul the wood to the railroad and receive from $6.00 to $8.00 per cord for the fruits of their labor. The not-too-arduous task of peeling this wood is frequently done by the old men and the women and children, and for this peeled wood an extra $2.00 a cord is paid by the mill.

The development of the pulp and paper industry has had a very great deal to do with the present prosperity of the Dominion. It has stimulated many of the older established industries by providing a market for their products, and has offered an outlet for the surplus labor not required during the winter months by our agricultural pursuits. Forest operations in Canada are necessary for our continued prosperity and it is with regret that we view the mute evidences of enormous potential economic losses in the blackened forests of eastern Manitoba,

northern and western Ontario, and eastern British Columbia. Such fire losses as we have sustained in the past must not be permitted to occur again.

Model Towns

The establishment and operation of a pulp and paper mill require the employment of many men.

Winter in the Model Town of Pine Falls, Manitoba.

The normal employment of labor at the pulp and paper mill at Pine Falls, Manitoba, is about 400 men and incurs an annual pay roll of over $800,000. These men are permanently employed and since the mill will remain in continuous operation for at least 20 years, the Paper Company have made provision for the comfort and convenience of these men and their families, by laying out and building a small town with all the modern conveniences of a city. Such model towns are provided for the employees of

a number of the Canadian pulp and paper companies, hydro-electric companies, and mining companies, where of necessity the plant is erected far from the centres of population and often far within the wilderness of rock and forest.

The Abitibi Power and Paper Company have provided a model town for their employees at Iroquois Falls, Ontario. Price Brothers & Company have two model towns one at Kenogami and one at Riverbend near Lake St. John, Quebec. Another such town has been established by the Aluminum Company of Canada at Arvida on the Saguenay River, Quebec, now housing 7,500 people, and planned for the requirements of 50,000. This town is provided for the workmen of the plant of the Aluminum Company, which includes one of the largest hydro-electric developments in the world.

The majority of employees in this class of industry are skilled or semi-skilled, necessitating the provision of a superior type of accommodation. The expenditure incurred in providing this accommodation is justified in the ratio in which it decreases the labor turn over, and adds to the contentment of workmen, which, in turn, is reflected in increased efficiency and production.

Unlike most communities, model towns do not have to pass through the long years of gradual development, but begin with all the modern conveniences which usually are acquired only after the lapse of time. Ideal living conditions are attractive, and give that measure of satisfaction to the workmen

and their families which produces contentment and continuity of labor. This in turn is reflected in the economic and continuous operation of the industrial plant. It is highly important that hydro-electric power plants and pulp and paper mills should operate continuously and efficiently, for many industrial establishments scattered throughout the neighbouring country are dependent upon them for their operation.

The accommodation to be provided in a model town classifies itself under three headings: (1) General accommodation for the officials and for the skilled and unskilled workmen, which in turn is based on rates of wages paid and rentals to be fixed; (2) The commissary necessary for the providing of adequate provisions, fuel, clothing, etc.; (3) The educational, religious and social activities, such as schools, chapels, hospital, recreation facilities and general community work.

The Model Town of Pine Falls

As an illustration of a model town, that provided by the Manitoba Paper Company, may be taken as a good example of what other pulp and paper companies are providing their employees. The town site of Pine Falls on the Winnipeg River has been developed along the most modern and economical lines known. The preliminary studies investigated the best aspects of other industrial communities and resulted in the laying out of a garden village, some of the features being, that there are no straight

lines to the streets, and no lanes, and that ample reservation is made for planting spaces, garden islands, etc.

The development circles around the village green which contains the foot-ball field, tennis courts, bowling greens, and shaded paths. This follows out the old English idea of village development. The village green, etc., is in the shape of a spheroid the base of which faces on a double boulevard with an island park running through the centre. The business block is laid directly opposite the base of the spheroid and beyond the double boulevard. This business block is designed to provide ample space for stores, shops, community club, theatre, hotel, bank, postoffice, and other business necessary to the community. All streets radiate in circles around the business block and village green. One of the features of a layout such as this is that there are no direct north, south, east or west exposures.

The Pine Falls townsite was laid out in 1927, during which year 110 modern dwellings were erected. The houses are of stucco, each differing in architecture from its neighbor and ranging in size according to the needs of the occupants for whom it is intended. Each lot is large, well treed, and the houses are well removed from their neighbours. Carefully purified water and sewage connections are supplied to every house, while a full complement of fire hydrants takes care of the fire hazard. The pole lines carried down the rear lot divisions, make it possible for the housewife to use all the electrical

School, Pine Falls, Manitoba.

appliances known to the city. An incinerator has been installed and the Company daily carries out a complete system of garbage, ash, and refuse disposal. A thoroughly up-to-date hospital containing fifteen beds, an X-Ray machine, an operating room, a

Hospital at Pine Falls, Manitoba.

staff of nurses and two resident doctors are available to meet any emergency of accident or ill-health.

Education of the children is provided for in a five-roomed school costing $42,000. The school contains the best equipment available, an up-to-date chemical laboratory, and is operated under the direction of the Provincial Department of Education. With five well qualified teachers in charge, the work up to, and including Grade XI, is now being taught.

Recreational centres are provided in a skating rink, curling rink, two tennis courts, and a nine-hole golf course. Baseball, football, rowing and other sports are encouraged by the Company, while a temporary community hall provides facilities for dancing, motion pictures, badminton, and basket ball.

The town was carefully planned before ever a building was erected or a street cleared and, when completed, should be a model town for an industrial centre. This year more homes are to be built, a church erected, and a permanent community hall provided, so that, in the near future, there will be little lacking at Pine Falls for the welfare of the community.

THE PINE FALLS MILL

To give an intelligent idea of the processes whereby wood is converted into pulp, it is necessary to follow the course of the wood from the time it enters the mill until it appears as pulp ready for the making of paper. The Pine Falls mill, now owned

by the Abitibi Power and Paper Company, is a good example of a modern pulp and paper mill.

During the summer of 1926, the first pulp and paper mill to be erected in Manitoba was built by the Spanish River Pulp and Paper Mills Ltd., at Pine Falls about eight miles from the mouth of the Winnipeg River. This mill built throughout of concrete, although not one of the largest in Canada, possesses the very latest improvements in design and pattern. Two kinds of pulp are manufactured, groundwood pulp (mechanical pulp) and sulphite pulp. The newsprint manufactured consists of 75 per cent. groundwood pulp and 25 per cent. sulphite pulp.

Two paper machines, each 226 inches wide and capable of operating at 1,025 feet per minute can provide an output of 250 tons of paper per day. The machines run night and day, excepting Sundays. In order to operate such a mill with the maximum efficiency, almost perfect co-ordination of the various units is required, for the process from the raw material, (sticks of spruce four feet long) to the finished product, is practically continuous. No large supply of stock material other than the wood is kept, and consequently any break-down in the process may prevent the operation of the paper machines each of which is producing paper at the rate of 1,000 feet or more per minute. A 226 inch machine can produce paper 214 inches wide.

The control of this plant is in the hands of a staff of specially trained, highly capable, operating

engineers, assisted by a chemical laboratory, whose staff control, especially, the manufacture of the chemical (sulphite) pulp. The chemists also keep a close check upon the paper making qualities of the pulp provided hour by hour from the grinding room and the storage tanks of the sulphite plant. Scientific control from beginning to end marks the operation of this modern mill.

THE PULPWOOD

Wood-cutting operations are carried out during the winter season only. Spruce, with a little balsam, are the only trees cut. The wood is hauled to the Winnipeg River, or one of its tributaries, and piled on the ice ready to be floated down in the spring. Other large quantities of wood are hauled directly to the mill, and some to the railway, where it is readily transported to the mill. Farmers and settlers cut wood off their own property and sell to the paper company, while a considerable quantity of wood is cut by private concerns operating wood-camps in the timbered areas of north western Manitoba, the Inter-lake region and to the east of Lake Winnipeg. No special wood-cutting operations are employed since the timber is all small and can be handled by the axe and saw. The erection of this mill less than 80 miles from Winnipeg, combined with the operations of the Kenora and Fort Francis mills, has been very stimulating to the winter activities of the province and has materially

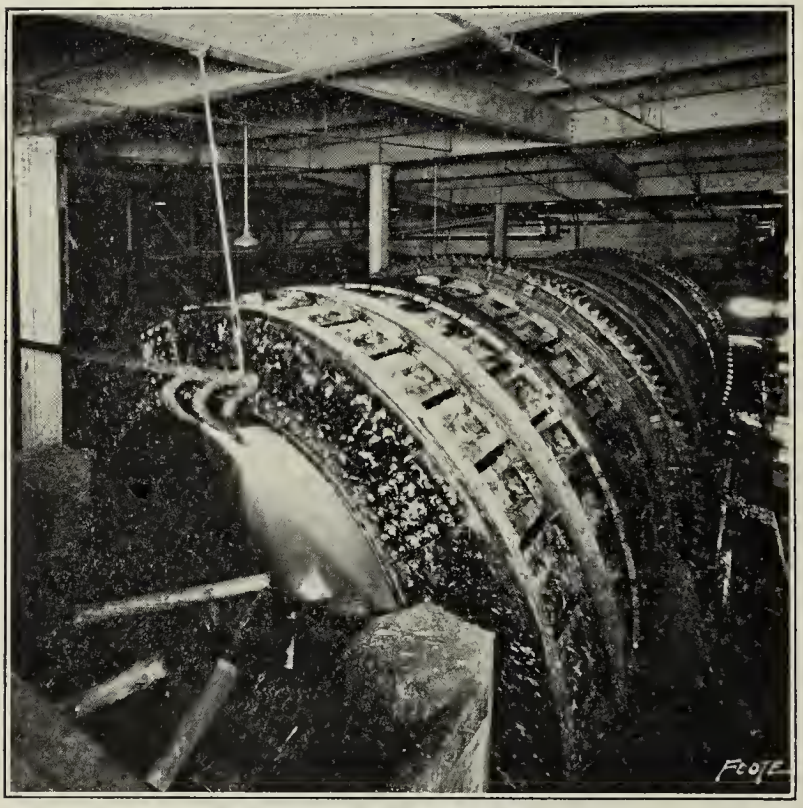
diminished the number of the unemployed of the City of Winnipeg.

Barking the Wood

Pulpwood for making groundwood pulp is cut into four-foot lengths and then barked. It is necessary to remove the bark, as if left on, it would discolour the pulp, reduce its commercial value, and would add little or nothing in the way of fibre to the pulp. Moreover, the bark is largely soluble in the chemicals used in the sulphite, soda, and sulphate processes and consequently if left on would use up the chemicals in the cooker or digester. The modern barking machine, such as is used at Pine Falls, is a large iron drum 12 feet in diameter, 45 feet long, open at both ends and revolving at about six revolutions per minute.

The revolution of the barrel-like drum tumbles the sticks of wood against each other and knocks off the bark. Fresh wood is fed in at one end while the rossed sticks are shoved out at the other end. The speed at which the wood is fed in depends upon the previous history of the wood and the season of the year. If the wood has been brought to the mill without having been in the water at all, it will take twice as long to remove the bark, as for wood which has been in the water for six months or more. Wood is more difficult to bark in the winter time and as water transportation is impossible, it is customary to bark enough wood during the summer to run the mill

through the winter. The rossed wood is conveyed from the barking drum to the foot of the stacker as shown in the accompanying photograph. The bark

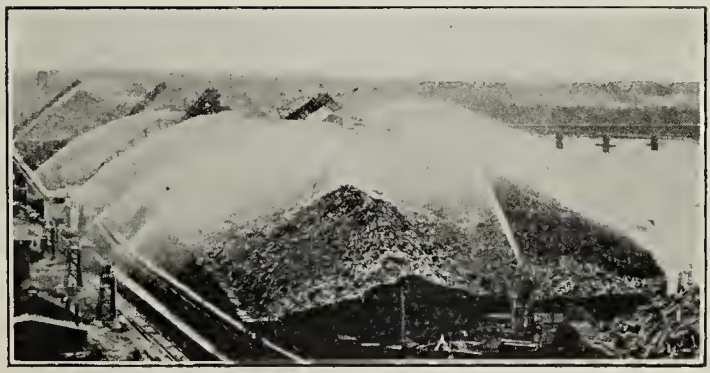


Barking drum at the Manitoba Pulp and Paper Company's Mill, Pine Falls, Manitoba.

from the barking drum is conveyed to a press where a large percentage of the water is pressed out of it. When mixed with a little coal the pressed bark will burn, and is used under boilers as fuel for generating steam.

Stacking Pulpwood

The reserve supply of stacked wood is one of the most striking sights in the fall of the year at any large paper mill. Seldom does one see so much wood in one place at one time, and as the quantity runs up into the hundreds of thousands of cords, the



Wood stack and monitors, International Paper Company's Mill, Three Rivers, Quebec.
Nearly 5,000 gallons of water a minute are being poured over this huge pile of pulpwood. Wet wood is slow to rot and will not catch fire.

huge pile is a never-to-be-forgotten sight. Throughout the summer the piles of wood are sprayed with water, partly to prevent the outbreak of a fire and largely to reduce the loss of wood from fungous growth (rotting) to a minimum. Wood that is saturated with water—its cells completely filled—will not rot. Wood below a 20 per cent. moisture will not rot, but when the moisture-content lies in between these two limits, fungous attack may be expected. The most rapid fungous growth takes place

at a moisture content between 30 and 40 per cent. The most efficient protection against rotting is to keep an artificial blanket of fog over the whole pile, and this is done by means of spray nozzles called monitors, distributed at intervals around and over the piles.

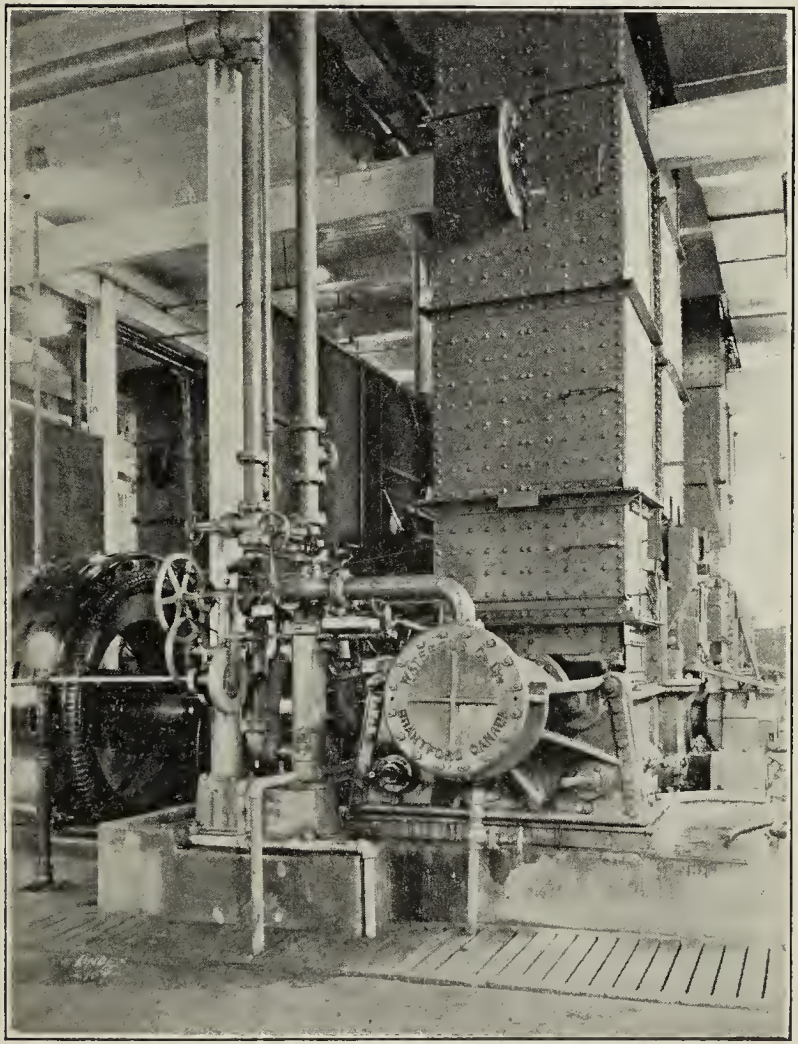
Fungous attack does not destroy the volume of the wood but does destroy the weight. The fibrous character of the cellulose is destroyed by rotting and consequently the quality and the yield of pulp are markedly affected. Rossed wood is seldom left unused from year to year since the loss by decay is progressively faster as time elapses. The maximum storage for spruce is four years and for balsam two.

Fire Hazards

These huge piles of wood constitute a grave fire risk. The loose nature of the stack provides ample access of air and if a fire broke out at the bottom of the pile it would be almost impossible to extinguish it. Each pound of wood consumed requires a gallon of water to absorb the heat produced in its combustion. The rate of burning in a pile of dry pulp wood is so great that it is impossible to provide water fast enough to absorb the heat being generated, and consequently, the only safe protection against fire is that of prevention by keeping the pile saturated at all times with water.

The Magazine Grinders

Mechanical pulp is made by grinding the four foot lengths of barked wood. At the Pine Falls Plant



Grinders for making Ground Wood Pulp, Kenora Paper Co., Kenora, Ontario.

Barked 4-foot lengths of Spruce wood are piled from the floor above into the rectangular steel towers seen on the right. The motor-driven sandstone grinder is located at the base of each tower. The pipes and valves for regulating the flow of cold water on to the stone are seen in the foreground.

this operation is done in magazine grinders, which consist of vertical rectangular towers 50″ x 39½″ and about 18 feet high. At the bottom of the magazine is a grindstone about 62 inches in diameter and 4 feet or more in width, filling practically the whole base of the magazine. These grindstones are made from a special variety of sandstone quarried in Ohio and Virginia. The surface of the stone is roughened by "burring" so that the wood will be disintegrated when pressed against the rapidly revolving drum. The grindstone is rotated by a synchronous motor and revolves at about 225 revolutions per minute. This gives a speed of almost three-quarters of a mile per minute to the outside of the stone in contact with the wood.

Large quantities of cold water are showered on to the wood and stone, to prevent the wood charring or catching fire from the heat generated by the friction of the wood against the stone. By governing the heat generated the quality of the pulp can be controlled. Even with the stream of cold water flowing on to the wood the pulp and water running out from the base of the grinder is between 120° and 140° Fahrenheit, all of the heat generated coming from the friction of the wood against the stone.

The pressure of the wood against the stone is regulated either by hydraulic rams operating against the wood, or, as at the Pine Falls plant, by caterpillar chains with flanges bearing against the sticks of pulpwood. The regulation of the pressure

is extremely important since the consumption of power and the output and quality of the pulp are proportional to and vary with the pressure. The horsepower to the grinder increases directly with the pressure of grinding, but the horsepower per ton of wood ground, decreases with increase in pressure. Thus by increasing the pressure on the stone by 2½ times the output of pulp is increased about threefold. The speed of the stones is usually kept well below that required by a consideration of safety in operation.

During the summer the operation of the grinders is somewhat modified so as to remove more of the pitch which is apt to separate and clog up the paper machine, and to allow for the softer nature of the wood itself in warm weather. A finer cut burr on the surface of the stone is used and less of the so-called "white water" is returned from the pulp-washing operations to the grinders. The finer burr produces shorter fibres and lowers the grade of the pulp produced.

The pulp-maker is constantly on the watch, regulating controllable variables, in order that the quality of pulp delivered to the paper machines may be as nearly uniform as possible.

Sulphite Pulp

Paper made from groundwood pulp lacks strength owing to the shortness of the fibres produced in the grinding process. Groundwood pulp contains all of the ingredients of the natural wood and since these

undergo change on exposure to the air, the paper in time becomes yellow. The resins and lignins in the raw wood are largely responsible for this deterioration due to oxidation by the air. Paper made from groundwood pulp alone becomes quite brittle in time and breaks very easily.

To increase the mechanical strength of paper made from groundwood pulp, up to 25 per cent. of long fibred chemical pulp is mixed with it. The long fibres of the chemical pulp form a matte into which the shorter fibres of the mechanical pulp settle, and the whole forms a much stronger paper than that made from the short fibred stock alone. Moreover, the removal of the lignins and resins by the chemical process provides a white pulp not coloring with age. This stock, therefore, adds to the appearance of the paper and largely prevents the developing of a yellow color.

The Pine Falls Plant employs calcium bisulphite as the chemical for dissolving the resins and lignins. This chemical reagent is prepared by the action of water containing sulphur dioxide upon limestone. The sulphurous acid formed dissolves the limestone, forming calcium bisulphite. This salt, together with sulphurous acid, is held in solution in the water and when kept in contact with the wood for about 10 hours at a high temperature and 70 pounds pressure dissolves all the materials except the fibres of cellulose. The wood is disintegrated into individual fibres. The fibres are practically unattacked in this process and consequently are preserved in their en-

tirety, quite in contrast with the crushing and tearing of mechanically ground pulp.

The Preparation of Sulphur Dioxide

There are two methods in use for preparing sulphur dioxide gas, one, by burning sulphur in air, the other, by roasting metallic sulphides such as iron pyrites in air. The relative price of sulphur and pyrites laid down at the paper mill determines which method will be employed. In Canada and the United States sulphur is the cheapest, while in Europe, pyrites is almost exclusively used. The economical recovery of sulphur from the large underground deposits in Texas and Louisiana has displaced pyrite burning in America. An engineer, Frasch by name, conceived the idea of drilling into the sulphur beds and forcing hot water under pressure down into the sulphur. The hot water melts the sulphur, and then by the use of compressed air the mixture of liquid sulphur and water is brought to the surface and poured on to the ground where the sulphur solidifies and the water runs away. Huge bins 1,000 feet long, 200 feet wide and 40 feet high are filled in this way. When the sulphur is desired for shipment the mass is disintegrated by dynamite, loaded by steam shovels into the railway cars and sent in trainloads to the paper mills.

The sulphur is burned at the mill in 15 foot long, rotating, cylindrical, steel burners which are fed with sulphur contained in a hopper directly above. The heat of combustion melts the sulphur which

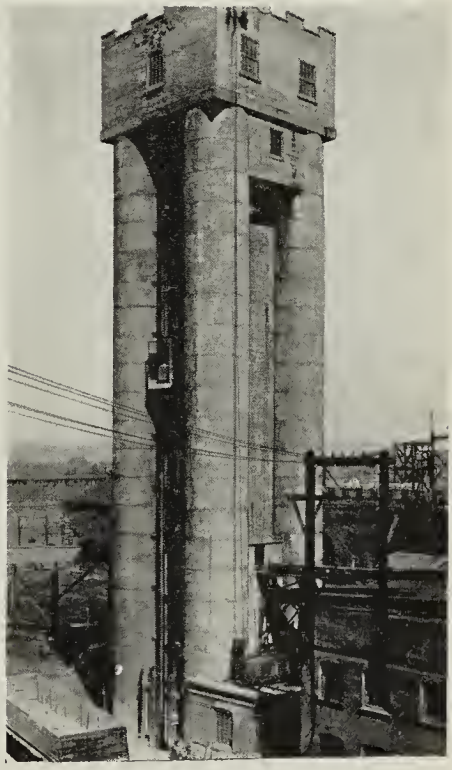
runs down into the slowly revolving burner. A suction fan pulls the sulphur dioxide out through a water cooling system directly into the base of the limestone-loaded towers.

The Limestone Towers

Modern sulphite mills possess two limestone towers built of concrete. Both are filled from the top with limestone. Use is made of the "counter current principle" to secure the most efficient absorption of gas, and the highest concentration of acid. Fresh water is sprayed over the top of the limestone in one tower and trickles down to the bottom. From here it is pumped to the top of tower number two and trickles over the limestone to the bottom. The gas from the sulphur burners enters at the bottom of tower number two and meets the descending weak acid and dissolves in it. The excess gas is conducted from the top of tower number two to the base of tower number one where as it ascends it meets the fresh water coming from above. The fresh water is able to dissolve all the residual gas and nothing but oxygen, nitrogen and carbon dioxide (from the limestone) escapes at the top of tower number one. The air entering the sulphur burner is so regulated that very little free oxygen passes out with the products of combustion. The mixed gases leaving the burners contain about 17 per cent. of sulphur dioxide.

Weak acid liquor is pumped from the bottom of tower number one to the top of tower number two

where it becomes strong acid liquor on its passage downwards, since it is meeting the strong acid gas coming up from the burners. The strong acid liquor from the base of this tower is pumped to a storage tank. The limestone in the strong acid tower becomes used up first; so provision is made for changing the gas and acid liquor from one tower to the other the weak acid tower becoming the strong acid tower and vice versa. This alternation is made daily. It is possible to add fresh limestone to the top of the weak acid tower while the liquor and gas are running, so the process becomes continuous without the necessity for *cutting out* a tower in order to recharge it with limestone.



Sulphite towers of a Modern Paper Mill.

Digesters

Pulpwood to be treated by the sulphite-acid liquor must first be chipped in order that the liquor and

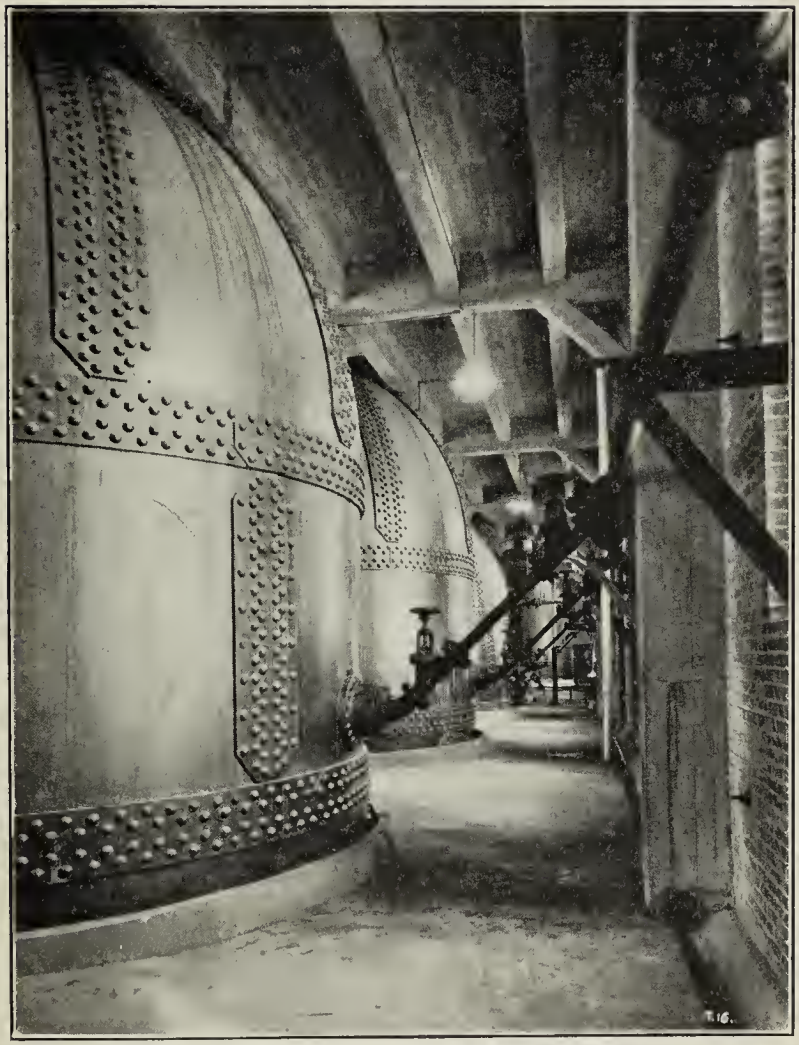
the wood may come into intimate contact with each other. This is done in the chipping room to which the barked wood is conveyed. The chipping machine is a rapidly revolving disc, set with knife-blades, which cuts the wood into small chips. These are screened to proper size and conveyed to a bin at the top of the digester room. Some paper mills dry the chips before storing them in the chip bin .

The average composition of dry spruce wood chips is:

Cellulose (wood fibre)	53.0%
Sugar	14.0%
Lignin	29.0%
Protein	0.7%
Fats and Resins	3.3%

and consequently it is seen that 47 per cent. of the dry weight of the wood is to be removed by the chemical action proceeding in the digester. The digester in a modern paper mill is constructed of steel plates and lined with acid-resisting brick laid in acid-resisting mortar. Digesters are cylindrical in shape with tapered or cone shaped top and bottom and range from 24 feet to 70 feet in height and from 8 feet to 17 feet in diameter. The small digesters hold about 2½ cords of chips while the large ones contain over 40 cords.

As the temperature and pressure at which the cooking of the chips is carried out is very important, each digester has an automatic recording thermometer and gas pressure gauge, the first inserted at the bottom of the digester and the latter near the



A Battery of Digesters in the Hawksbury Paper Mills of the Riordon Company (Canadian International Paper Co.) The chips are dumped into the digesters from the floor above, while the pipes for introducing the steam are seen on the right.

top, whereby a continuous record is obtained for the whole process.

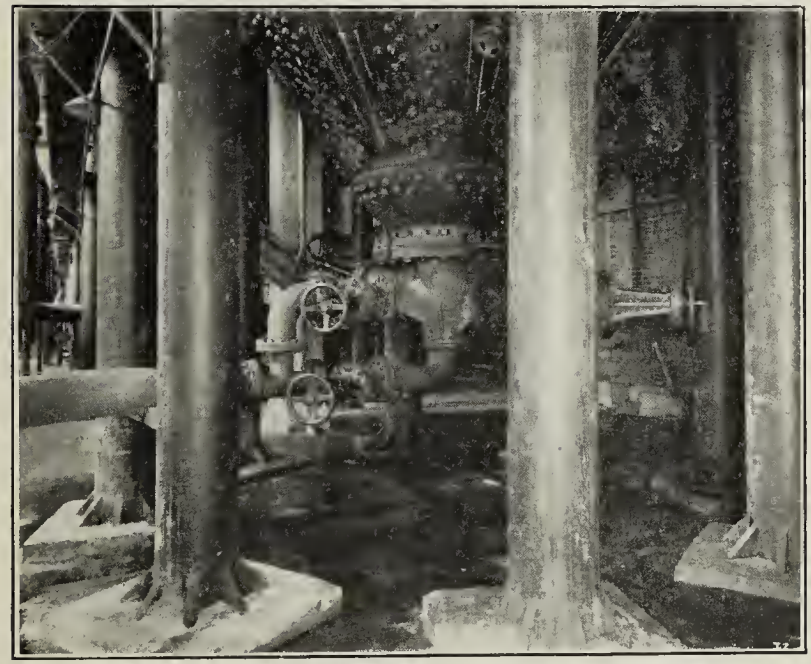
Cooking Process

The requisite quantity of chips from the chip bin is dropped into the digester, followed by the right amount of acid-liquor from the storage tank. Steam is then forced in until the digester contents come to the desired temperature, usually 145° C. to 150° C. Meantime an accumulation of gas, due to the chemical action taking place, causes an increase in pressure and this excess gas is permitted to escape along with a considerable quantity of acid liquor. This gas (largely sulphur dioxide) and liquor are either returned to the acid storage tank or the gas alone is recovered and passed back to the base of one of the limestone towers.

The cooking proceeds for several hours, usually nine to twelve but depending upon the quality of the chips, their water content, and the quality of pulp desired. Samples of the cooking liquor are removed from time to time and analyzed by the staff of chemists, while, at the same time, the pressure and temperature charts are carefully studied. When the chemist and chief cooker are agreed that the analysis of the liquor indicates the cooking process to be complete, the contents of the digester are blown out at the bottom into a large wooden tank. A steam pressure of from 65 to 70 pounds is employed for the blowing out process.

Blowing and Washing

The blow pit or tank is provided with a so-called *target* of bronze or iron against which the partially disintegrated chips are blown. The impact of the



The Base of a Digester.

When the chips are properly "cooked" in the sulphite liquor, the contents of the digester are blown out by steam through the large pipe on the left into a wooden tank where the acid liquor is later washed away.

chips against the target practically completes the disintegration of the chips into pulp. The pulp in the blow pit is now washed with quantities of warm water or *white water,* the wash waters usually being permitted to drain out into the waste pipe. When

it is remembered that 47% of the wood is dissolved by the chemical treatment, one realizes what a wasteful process the present practice is.

Utilization of Waste Liquor

Many organic compounds are formed by the reactions going on in the digester. These compounds, however, occur in such a dilute form that their recovery by evaporating the excess water is a very costly one. Only about 12 per cent. of the liquor blown out of the digester is solid material in solution. If this liquor be evaporated a product with adhesive properties is obtained, which may be used as a road binder, a binder for briquetting coal dust or other powdered materials, or as a core binder in foundries. Evaporated to 50 per cent. concentration, or to dryness, the substances may be utilized as fuel.

Processes for recovering ethyl alcohol from the sulphite waste liquor have been developed in late years. About one per cent. by volume of 95 per cent. alcohol is recovered, but it is difficult for alcohol prepared in this way to compete economically with that produced in the fermentation of molasses, the waste liquor of the sugar process.

Yield of Pulp

The resin in the wood is not all removed by the cooking process and resinous woods are therefore not adaptable to the sulphite process. Spruces, balsam, fir, hemlock and sometimes small quantities

of white fir, tamarack, yellow pine and poplar are usually used for preparing sulphite pulp. The yield of fibre depends to some extent upon the wood used, and also upon the strength of acid, and the temperatures within the digester. At too high temperature or with too great strengths of acid, some of the fibre may be dissolved and thus lost. The penetration of the acid liquor into the wood should be uniform, and consequently uniform size of chips is desirable in producing a yield of pulp of uniform quality. The yield of dry pulp varies, the production of one ton of pulp requiring between 1.7 and 2.2 cords of wood. As mentioned before, the quality of the pulp produced, and the yield are determined largely by the care exercised in operating the digester.

After screening to remove splinters, uncooked knots, and chips, pulp from the groundwood grinders or the sulphite mill is passed over cylinders inside which a vacuum is maintained thus removing most of the water. After sufficient thickening the pulp is pressed into cakes and may either be stored in piles or shipped to paper mills. At Pine Falls all of the pulp is immediately made into paper, but at other plants a considerable quantity of the pulp in the form known as laps is shipped to paper mills.

CHAPTER VII

THE PAPER MACHINE

Preparing Pulp for the Paper Machine

Mechanical pulp, or groundwood pulp, as it comes from the grinder pit is a mass of separated wood fibres of varying size, together with slivers of wood and unground slabs. Chemical or sulphite pulp coming from the washing tank contains knots and partially cooked chips together with pieces of the digester brick, cement, etc. In both cases the first quality pulp must be separated from the coarse and refuse material.

Screening the Pulp

The separation of the unground wood and slivers from the groundwood pulp is accomplished by mixing the pulp with a large amount of water, and pumping the liquid mass through metal screens in which the perforations are small enough to keep out the coarse material, but fine enough to let the desirable pulp pass through. The holes are usually from $\frac{3}{8}$ to $\frac{3}{4}$ of an inch in diameter, but the size varies in different mills and for the different purposes for which the pulp is desired. The slivers and

slabs are collected, dried, and used as fuel under boilers for generating steam.

Chemical pulp is also screened, but since the water in this pulp is more readily removed than in groundwood pulp or, as the paper maker says, the stock is "free", finer screens may be employed. The first screening of the chemical pulp is carried out with as little agitation as possible in order to prevent the objectionable refuse breaking up and entering the pulp.

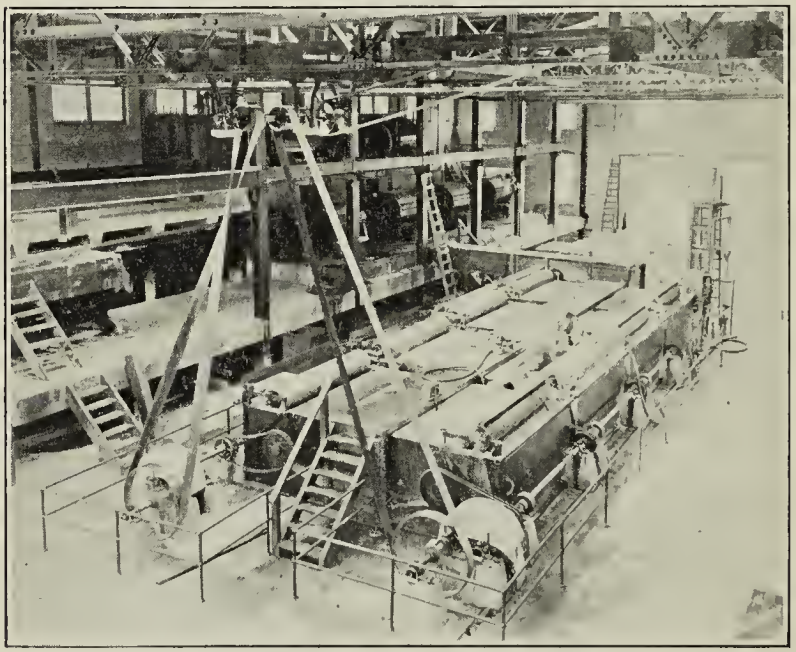
Sometimes the mixture of pulp and water is permitted to flow gently over a series of baffles which hold back such heavy materials as pieces of cement, and digester brick, while the water and pulp flow along. The riffling process, as this operation is called, is always conducted before the fine screening.

FINE SCREENING

After the foreign matter and the coarse splinters, etc., have been removed, the remaining paper-making pulp may be screened to separate fibres into various grades according to their length. This is done by selecting screens with apertures or slits designed to permit fibres of a certain length to pass through, and in this manner the paper-maker can separate a mass of pulp into several grades, each screen passing pulp with properties required for the special paper desired. There are several kinds of screens and various types of apparatus employed for the fine screening process, but it is only where pulp for making different kinds of paper is

required, that fine screening is necessary. Pulp for newsprint paper does not require fine screening.

After screening, the pulp is practically ready for paper-making. Some mills conduct the pulp from



Decker Room, Kenora Paper Co., Kenora, Ontario.
The tanks in the centre of the picture are filled with pulp from which water is being removed through suction applied in the long horizontal cylinders.

screens and use it directly on the paper-machine, while other mills pass the pulp through a thickening process called "deckering" whereby the water content is reduced. Screened stock contains from 99.50 to 99.75 per cent. water. After passing through the decker some water is removed and the

percentage of pulp is increased from 0.25 per cent. to 3 or 4 per cent. The water removed is passed back into the pulp mill to be used for thinning fresh stock in preparation for screening. Because of the short fibres present in this water it is white in color, and goes by the name of "white water." Any "white water" before rejection into the sewer is treated either by a filtering or a settling process, whereby the pulp still present in it is removed and saved.

Pulp for Shipment

Many pulp mills ship the product to paper mills at a distance, but sometimes it is desirable to keep a storage supply of pulp on hand. The first process for removing the water is to pass the pulp through rollers which squeeze the water out in much the same manner as it is squeezed out of wet clothes by a wringer. The pulp comes through the wet press machines in sheets. These are folded or lapped into a bundle and either shipped or sent to the press-room where the bundles are subjected to hydraulic pressing, whereby a further quantity of water is squeezed out. The lap bundle contains between 55 per cent. and 70 per cent. water while hydraulic pressing reduces the water content to less than 40 per cent. Further reduction in the water content may be brought about by drying the pulp in a drying room, a rather expensive process.

The condition in which pulp is shipped is largely determined by the distance the pulp is to be trans-

ported. It is a question of the freight cost of transporting water in relation to the cost of removing the water. Pulp shipped a long distance will be dried as completely as possible, whereas, where pulp and paper-mill are together, the stock, containing as high as 99.75 per cent. of water, will be conveyed directly to the paper-mill.

The Making of Paper

The manufacture of paper should always be carefully distinguished from the making of pulp. Pulp is merely one of the raw materials entering into the manufacture of paper Other raw materials consist of clay, infusorial earth, sizing materials, dyes, etc. There are many large paper-mills which do not manufacture pulp at all but buy all their raw material from pulp-mills, while these latter mills stop with the making of pulp and do not proceed to the manufacture of paper.

The Beating Process

Before entering the paper machines for making the finer grades of paper, pulp is subjected to a treatment designed to break up the bundles of fibres in order to make the fibres of more uniform length, and to increase their flexibility. This is done in a machine known as a beater, of which there are several kinds. One of the most interesting effects produced by the beating process is the curling up of the two ends of each individual fibre. This is done by the blunt knives of the rapidly revolving

beater-rolls bearing on the bed-plate as the pulp passes through between them. The tiny fibres are stroked out by the blunt knives in somewhat the same fashion that a hairbrush strokes out human hair. This curling of the fibres enables them to grasp and entwine each other in the manner usually denoted as "felting" and the strength and toughness of the resulting paper is largely dependent upon the success of this curling treatment in the beater.

The beatermen feed into the beater the various ingredients required for the particular paper being made. These may consist of groundwood pulp, sulphite pulp, sulphate and soda pulp in the desired proportions, coloring matter, sizing, filler, etc., all in definite, predetermined proportions. These predetermined proportions are known as the "Formula" and every grade and kind of paper has its own particular formula.

Should the beater not provide a paper stock of uniform consistency, as for example, stock still containing some bundles of fibres, it is run through a machine known as a "Jordan." This consists of a conical cast-iron shell the inside of which is fitted with long narrow steel bars. Revolving within this cone is another, also provided with steel bars, and so set that the clearance of the bars of the outside and inside cones is a very minute distance. The inner cone, or plug, revolves at from 300 to 350 revolutions per minute. The bars are arranged somewhat like the blades of a lawnmower in respect

to the bedplate so that a shearing cut rather than a direct cut is delivered to the pulp. The Jordan machines are massive and require from 75 to 250 horsepower to operate them,

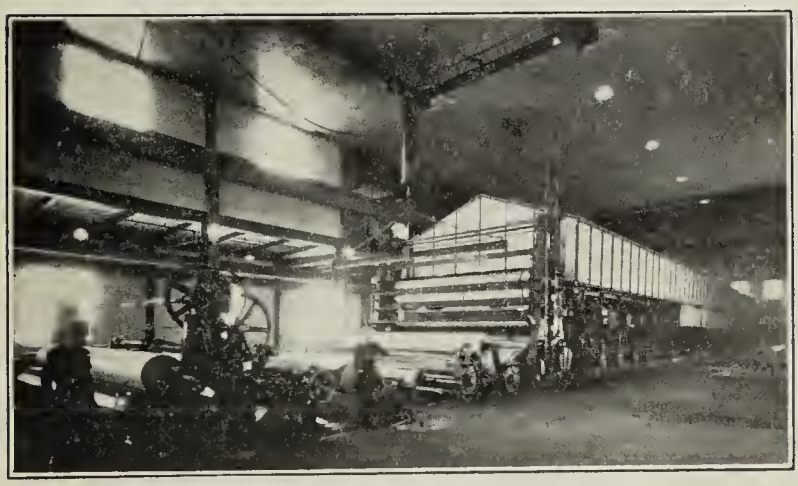
The course of the pulp through the beaters and Jordans is modified for the grade of paper desired, newsprint requiring less treatment than the better grades of paper. The pulp, after a final screening through screens much finer than any previously employed, is now ready to pass on to the paper machines.

The Paper Machine

The modern paper machine is a rapidly revolving monument to man's ingenuity in providing mass production of a common commodity. A paper machine in operation, and the news press, or printing machine, of a large newspaper, are amongst the most impressive machines illustrating man's mechanical genius, that this civilization affords.

The paper machine for manufacturing newsprint is the largest of all such machines and in general design may be taken as typical of all. It consists essentially of four consecutive but separate units synchronized to operate at uniform speed throughout. Pulp diluted with 99.5% of water, and known as *stock* is fed in at one end and within half a minute appears at the other end as dry paper, surfaced, rolled and ready for shipment to the newspaper companies.

Paper Machine No. 1., Pine Falls, Manitoba.
View from the "stock" end.



Same machine viewed from the calender end.

The width of paper machines and the speed of their operation has been rapidly increasing, until now we have machines 304 inches wide operating at 1,500 feet per minute. The Great Lakes Paper Company are having two such machines built for installation in their mill at Fort William, Ontario. The Canadian International Paper Company are operating three machines 270 inches wide at their Gatineau mill near Ottawa, and a similar machine is in operation at Fort Frances, Ontario. The two machines at Pine Falls, Manitoba, are each 226 inches wide.

A paper machine consists essentially of a device for allowing carefully screened pulp of constant consistency, to flow on to a rapidly moving bronze screen made in the form of an endless belt as wide as the paper to be manufactured, and travelling constantly away from the tanks where the pulp flows on to it. The water in the pulp drains through the openings in the screen, the drainage being assisted by suction boxes placed under and in contact with the wire screen. To interweave and felt the fibres on the screen a shaking motion is imparted to the Fourdrinier wire, as the screen is called. This prevents the fibres from lying in any one direction and gives the criss-cross, interlocking arrangement upon which the strength of the sheet of paper depends. At the end of the screen farthest from where the pulp flows on to it is a pair of heavy rolls between which the film of fibres from the Fourdrinier bronze screen passes. As the film of fibres

from the screen contains much water, it is passed between heavy felt-covered press rolls to have more of the water squeezed out of it. Next, the film of fibres, always supported on a layer of felt, is passed over a series of steam-heated steel cylinders, called dryers. The layer of felt is an endless belt travelling with the paper towards the rear of the machine. Finally the paper reaches the end of the drying cylinders and is then passed between heavy calender rolls which put a surface or "finish" on it, and from the calender rolls it is wound and rewound on to reels, the rewinding removing any creases from the paper.

Since the passage of the paper through the machine is a continuous process, the reader can readily understand what a complex and intricate mechanism such a machine must be, in order that every part should be in perfect running order and perfectly adjusted to every other part. The necessity for this is apparent, when it is remembered that the stoppage of the paper-machine stops the production of that on which the several million dollars invested in the plant depends for earning the interest charges, and for the accumulation of profits.

Wet Felts

The felts in the form of endless belts, on which the film of fibres is carried from the screen through the press section to the drying rolls are made from the very best wool available. No other fibre than wool can be used in the preparation of paper-

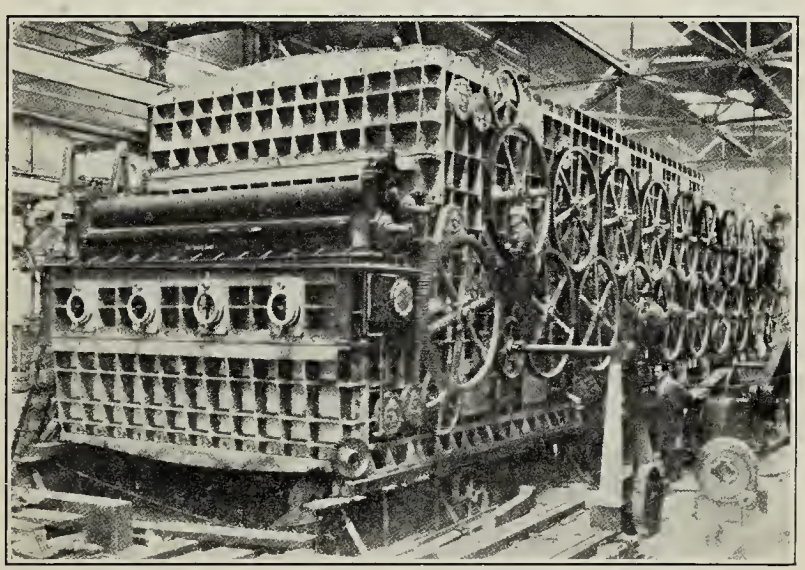
maker's felt. It is the only textile fibre which will pick up a sheet of wet paper from some other carrying medium, and deliver it again at any desired point without injuring the sheet, and with no particles of the paper stock adhering to it.

The woollen felt is woven from two kinds of yarn, one, the warp, running lengthwise of the felt and providing the strength necessary for the pulling required while running over the rolls. The second kind of yarn forms the cross threads, and is the surface on which the paper rests. The cross threads have the nap raised so that the finished paper will not carry an imprint of the threads. The main object to be gained is a felt of the greatest possible strength and resistance to friction, together with a texture so loose as to admit of the maximum removal of water from the sheet of paper. Serving as a belt or carrying apron, it must possess a smooth and even surface, must run straight and true, the edges must be firm and it must hold the desired width while running day after day under the varying conditions existing on the paper machine.

On modern paper machines the felts are often over 60 feet in length. Suction boxes are placed under the felt at intervals to assist in removing the water, for the speed of operation of the modern machine is only possible by thus assisting in removing the water. A large machine requires three or even four such felts to carry the paper through to the calenders.

Should any little tear, crease, or other irregularity

appear on a felt it must be discarded and a fresh felt supplied. The cost of a single felt is between $400 and $500, and consequently the loss occasioned by discarding a felt is considerable, for no attempt is made to repair it. The felt, however, has a certain salvage value, in that it is cut up and sold as blankets and rugs.



Vacuum dryer at the Kenogami Mill of Price Bros. Co., Quebec.

DRYERS

The dryers over and against which the felt carries the paper, consist of a series of large, hollow, cast steel cylinders usually erected in a double row, one on top of the other and geared so they will all move at exactly the same speed. Heat is supplied by steam, piped into the cylinders, and provision

is made for carrying away the water of condensation. The surface of these cylinders is turned perfectly true, and is polished to a high degree to remove all tool marks and blemishes, and permit the paper to pass over them with a minimum of friction. Anything else than a smooth surface will ruin the paper. The felts used on the dryer rolls are not made of wool, but of canvas. After passing over the dryer rolls the paper has lost all but from 5 to 10 per cent. of its moisture and is ready for surfacing in the calender presses.

The introduction of vacuum dryers into the paper machine in place of the hollow steam cylinders shortens the length of the drying process, consumes less power, and permits a greater speed of operation. The Price Bros. Company, Lake St. John District, Que., have installed vacuum dryers in three of their mills last year and report them to be working very satisfactorily.

Calenders

The surface, or "finish", of a paper is provided by passing the paper from the dryers between heavy steel rolls. These rolls are placed in a vertical stack one above the other and are driven by the friction of the bottom roll. Such a vertical series of rolls is known as the calender stack and the number of rolls in a stack is determined by the quality of the surface required. Five rolls are sufficient to produce the surface required for newsprint while for some water finished papers three stacks of

10 cylinders each are employed. From the calenders the paper is wound on reels, then cut into the desired width and rewound for shipment.

Starting the Paper Through

When it is desired to start the paper machine all units are carefully examined to see if they are operating smoothly. All hands stand by when the pulp is ready to pass on to the moving Fourdrinier wire screen and at a given signal the pulp is permitted to pass on to the apron. When there are sufficient fibres present in the water to make the sheet of paper, the pulp is carried to the first press roll. A squirt gun squirts a needle-pointed stream of water on to the sheet of pulp, cutting it across with the exception of a few inches called a *tail-end*. This tail-end is lifted on to the side of the first felt and, pinched between guide ropes, proceeds through the machine as a narrow band of paper. If everything is running smoothly the width of this strip is gradually increased by withdrawing the squirt gun to the opposite side of the machine and a V-shaped piece of paper, increasing in width to the width of the machine, is soon passing through.

Should anything happen to the paper passing through, the squirt gun is employed to cut off the sheet of pulp. The cut sheet drops into a storage chest instead of feeding the machine, while the paper tenders rapidly and expeditiously by means of compressed air, blow out the torn paper from the presses and dryers, if possible without stopping

the machine. The starting process is now repeated from the end of the Fourdrinier wire where the squirt gun is operating.

Recovering Waste

All waste paper and pulp from the paper machine is returned to some part of the pulp-making process, and is prepared anew. All water, containing fibres, no matter where it has been used in the paper-making process, is passed through a "save-all," which is exactly what its name implies. All of the small fibres are removed from the waste water, or "white water" as it is called, by suction. The suction is applied through fine screens, the water passing through while the fibres remain on the outside. These are automatically scraped off and returned to the beaters where they again enter the pulp stream.

CHAPTER VIII

MAKING CLOTH FROM WOOD
RAYON

The Uses of Wood

At one time the only important uses for wood were as fuel, and for building purposes. Later the manufacture of charcoal for the smelting of iron ore and for fuel, resulted in the wasteful destruction of many of the original forests of Europe and eastern America, but of all the wasteful uses to which wood has ever been put, the preparation of lye from wood ashes used in the making of soap, probably surpasses all others. Whole forests in Europe and eastern America were cut down, burned, and the ashes collected and leached with water in order to obtain lye. Fortunately the chemists discovered a much easier and less expensive method of making lye without using wood ashes at all, and the wholesale destruction of the forests for this purpose ceased. The use of charcoal as a fuel and for ore-smelting is now almost obsolete.

Outside of building and planing-mill products, there are fifty groups of specialized industries using lumber, and new uses for wood are being

constantly developed. Telephone and telegraph companies use a million poles a year, while over a billion wooden fence posts are set up annually. The railroad companies use seventy-five million ties every year, and it takes forty years to produce a tree large enough to make ties. The Sunday edition of a Chicago or New York paper, with a circulation of over a million, uses the pulpwood from a spruce forest of seventy-five acres.

Utilization of Wood Waste

The utilization of wood waste is a very important matter. Sawdust is already used for a number of different purposes. When mixed with clay, and moulded into bricks or tiles after the firing process, a light porous product is obtained. Wood fibre and sawdust mixed with plaster of Paris is moulded and pressed into plaster board and plaster wall-board now extensively used by the building trade because of the lightness and the fire and heat resisting properties of the material. Sawdust, slabs, and other wood waste, when reduced to a powder-like flour, are used for absorbing liquid nitro-glycerine, and this, when moulded into sticks, becomes dynamite. Another interesting use to which sawdust has been put is in the formation of a variety of sugar called glucose. This can be fed to cattle, or if allowed to ferment, will produce alcohol.

Spruce oils, spruce gum, pine oils, turpentine, resin, tannin, creosote oils, tars, and pitch may be

recovered from abandoned stumps and roots. At the present time only one Canadian plant is recovering turpentine, and one on the Pacific Coast is recovering resin and turpentine from the bark of the Douglas fir.

It is possible to recover a number of valuable by-products by subjecting the chips of the spruce and hemlock to steam distillation before using them in the making of pulp. Wood alcohol, turpentine, turpentine oils, resin oils and other substances distil over, while a further treatment of the chips with a mineral oil will recover the resin. As yet, however, no pulp mills in Canada are treating the chips in this way, and all of these substances either go into the paper or into the waste liquors. The usual pulp-making processes are accompanied by a 50 per cent. loss in the weight of the original wood.

Several plants are in operation in Canada recovering a number of valuable products by the destructive distillation of hardwoods. The hardwoods, cut up into short lengths, are placed in an iron retort and heated from the outside. From the distillate, wood alcohol, acetic acid, acetone, tar and pitch are recovered, while a high grade of charcoal is left in the retort.

High Explosives

Apart from the making of paper, cellulose, the chief constituent of wood, has several other important uses. When cellulose is treated with a mixture

of nitric and sulphuric acids, substances known as cellulose nitrates are obtained. From these a number of very explosive substances are prepared, gun cotton, or cordite, probably being the best known.

Collodion or *artificial* skin is prepared from cellulose nitrate and has an extensive use in making photographic films, in making certain kinds of varnishes and as a starting material in the production of artificial silk. At one time photographic films were very combustible and dangerous, but now the collodion is treated with acetic acid, and a product is obtained which burns very slowly, if at all. When the *movies* first appeared, many fires and explosions occurred in the film room, but with the substitution of cellulose acetate for celluloid, the danger from fire and explosion was fortunately removed.

Celluloid

When cellulose is treated with nitric acid, a substance known as pyroxylin is obtained. When pyroxylin is mixed with camphor, a transparent, doughy mass known as celluloid and capable of being kneaded and pressed into any desirable shape is obtained. Many useful articles were formerly made from celluloid, but owing to its inflammable nature it has largely been displaced by cellulose acetate and other related products. These we may see made up into such articles as combs, the backs and frames for mirrors and pictures, the handles of tooth brushes, toilet articles of all kinds, collars,

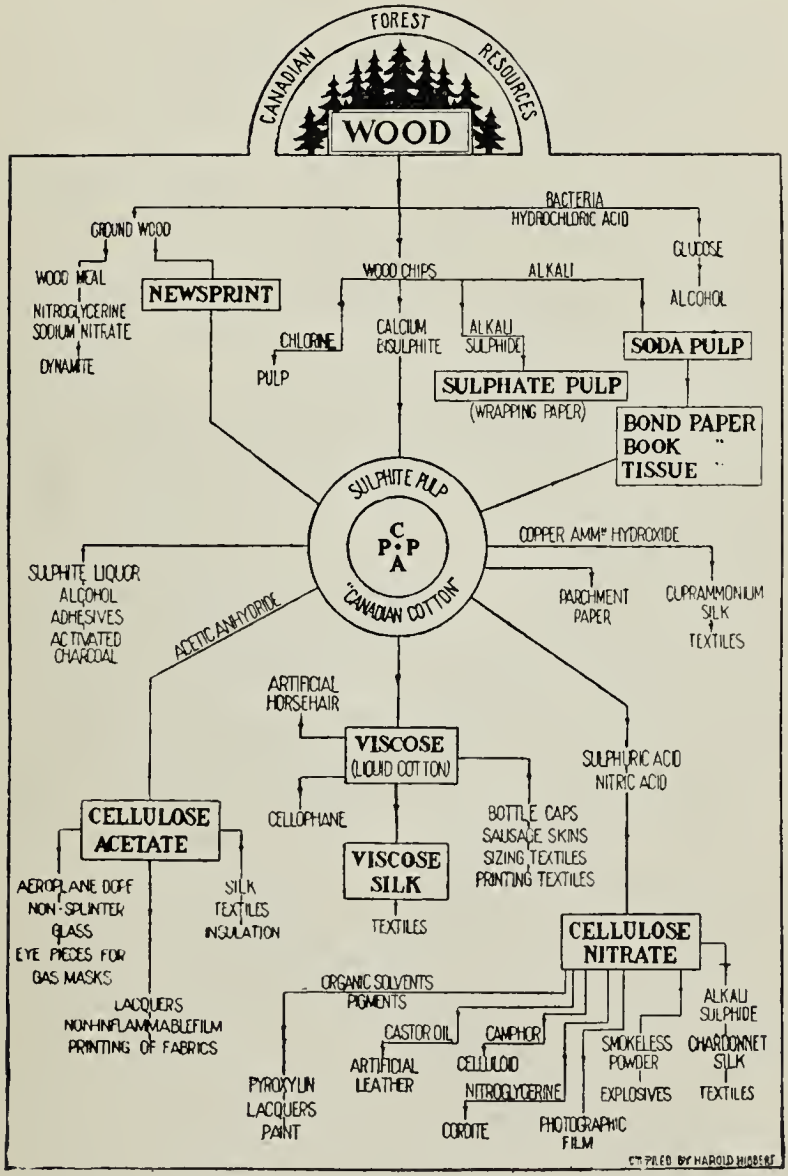


Chart of Wood Production.

dolls, sun visors, plates and boxes, and a large variety of electric insulating fixtures.

Artificial or Man-Made Silk

About forty years ago at the International Exhibition held in Paris in 1889, a new textile fibre was introduced to the world. It was made from waste cotton fibres and possessed many of the desirable properties of silk, but without its brittleness. Within a few years this fibre came into general use, first mixed with cotton, wool and natural silk fibres, but now, millions of yards of beautifully colored, soft, silk-like cloth are made from artificial silk alone.

The invention of artificial silk was based upon observing the work of the silk worm in spinning natural silk fibres after feeding on mulberry leaves. Mulberry leaves are largely composed of cellulose, and the silk worm, through the chemical processes going on in its body, is able to transform this cellulose into silk. Why then could the same process not be carried on in a kettle instead of in the body of a worm? A French nobleman, Hilaire de Chardonnet, was the first to produce an artificial silk having a commercial value. Cotton linters, or waste cotton after chemical treatment, were dissolved in a mixture of alcohol and ether, and forced out through small openings, producing threads of uniform size and any desired thickness. The production of thread in this manner is based on the same principle as

that used in forcing meat through a meat chopper. The meat comes out through the small holes in threads. By the use of plates perforated with holes of different sizes fine and coarse threads are produced at will.

The silk worm produces silk threads by ejecting through two small openings in its mouth a semi-liquid, viscous substance, which hardens on exposure to the air. These threads, unlike the artificial silk, are not produced under uniform pressure and are not of uniform thickness. The silk worm winds the 500 yards of thread so produced into a cocoon, and worm and cocoon are collected, packed into bales and if from China and Japan, are shipped by the very fastest steamships and trains to the silk mills of England, France and America. Other silk-moth eggs must hatch out into silk worms and feed on mulberry leaves before the natural silk thread factory begins operations again.

But with artificial silk the thread factory is working continuously day and night. Cellulose in the form of pure cotton, or spruce wood pulp, is continuously transformed into soluble cellulose by complicated chemical processes, and then formed into fine threads. These, on hardening, are spun into larger threads and yarns on special spinning machines, are dyed, and are then woven into soft, beautifully colored webs of cloth. Adam and Eve were content to dress themselves in green leaves. Later generations made use of the slow moving silk

worm to manufacture thread from leaves, but the present generation make much more beautiful clothing, much more expeditiously, not from the fibres of the leaves, but from the cellulose of the trunks and stems of the tree.

Advances in art and education have called for radical changes in the development of textiles. The

Twisting and Reeling Rayon.
Courtesy, The Industrial Fibre Co.

women in particular have acquired a greater artistic taste, and demand more lively combinations of colors, and designs of texture. The modern development of the textile industry has kept pace with this demand largely through the introduction of new dyeing processes, and the use of celanese, rayon or artificial silk.

Rayon, or artificial silk, is a soft, pliable, textile fibre possessing a fine lustre and capable of high

dyeing. Rayon partly loses its strength while wet, but on drying recovers its original strength. Because of its ability to absorb moisture, artificial silk makes an excellent material for the making of underwear. It absorbs the perspiration and permits the moisture to evaporate, thus keeping the skin dry and comfortable. Moreover, rayon does not

Plant of the Canadian Celanese Co., Drummondville, Quebec, where celanese silk is made from cotton linters and wood pulp.

rot or turn yellow, as does natural silk underwear, and when combined with cotton or real silk, is almost an ideal material for making shirts, underwear, and hosiery.

Artificial Silk From Spruce Wood

The long fibres of the spruce wood, after treatment by the sulphite process and bleaching, produce a cellulose from which artificial silk may be made.

Several of the large rayon manufacturing concerns use a mixture of cotton linters and spruce pulp as starting materials, but a new $3,000,000 plant at Drummondville, Quebec, is expecting to use spruce pulp alone. This plant makes use of cellulose acetate as one of the steps in the process of making silk. As already mentioned in this chapter, cellulose acetate has replaced the use of celluloid in the making of many useful articles.

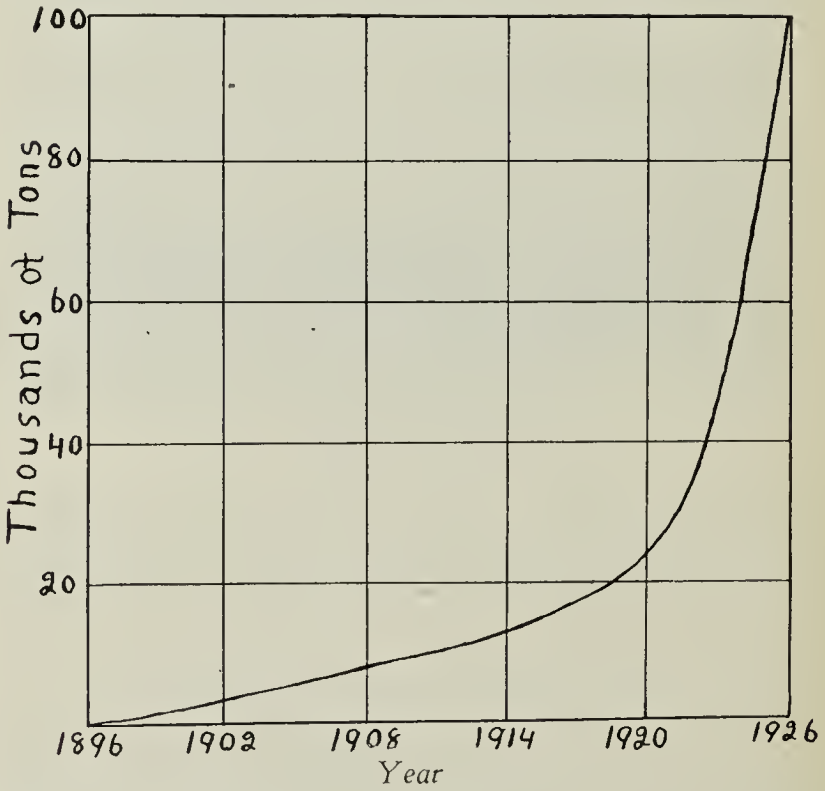


Chart showing growth in the production and use of artificial silk over the 30 year period, 1896—1926.

Purified spruce wood cellulose is treated with acetic acid and a related compound, acetic anhydride, in enameled iron vats. A little sulphuric acid is also added. The cellulose is soon dissolved and becomes cellulose acetate. When water is added, there separates out a white flocculent precipitate which, after being freed from all acids, is dissolved in acetone and made into threads of silk as already described. Artificial silk made in this way is known as Celanese silk, and is unlike viscose and other rayons in that it is not pure cellulose, but is cellulose acetate. Celanese does not lose so much of its strength when wet as does the pure cellulose silk.

The use of spruce wood pulp instead of cotton in the making of artificial silk is rapidly growing, and since Canada possesses the finest stands of spruce forests in the world, and also provides cheap hydro-electric power for operating the mills, the making of artificial silk is sure to become, within a very few years, a well established branch of the paper pulp industry.

CHAPTER IX

THE IMPORTANCE OF THE PULP AND PAPER INDUSTRY TO CANADA

The pulp and paper-making industry is the most important manufacturing industry in Canada, and of all Canadian industries the production of agricultural products alone surpasses it. In ten years the exports of wood and wood products increased from $83,000,000 to $283,000,000, and during the year 1928 500,000 tons was added to the production by the new mills constructed. Canada leads the world in the manufacture of pulp and paper. Newsprint is exported to twenty foreign countries, and in several of these it dominates the market. In one year, 1924-25, the exports to Australia and Argentina increased thirteen-fold, and to Great Britain nearly fourfold.

The first paper mill in Canada was erected at St. Andrew's, in Quebec, in 1803. At Crook's Hollow in Upper Canada in 1825, the first paper mill in what is now Ontario, was built. About 1870 Angus Logan & Company built the first wood-pulp mill at Windsor Mills, Quebec, while in 1887, the Riordons introduced the groundwood pulp, and the sulphite process, the latter at Merritton, Ontario.

In the census of 1871 pulp mills are not mentioned, but ten years later five mills are listed, with a total capital of $92,000, sixty-eight employees, and an annual output valued at $63,600. In 1928, there were 81 pulp mills and 71 paper mills operating in Canada, capitalized at over $510,000,000, employing about 35,000 men, and with an annual output valued at over $250,000,000.

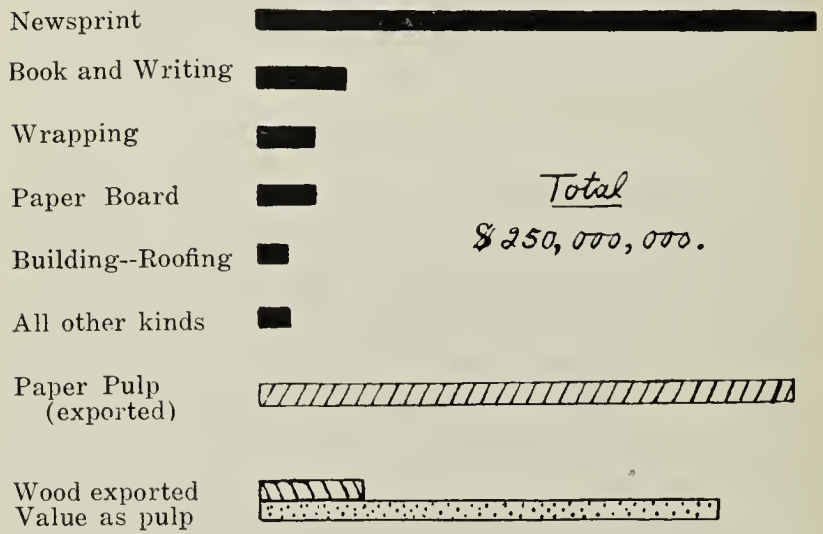
Huge Exports to the United States

The outstanding feature of the world's consumption of newsprint during the last few years, has been the phenomenal increase in the per capita consumption of the United States. During 1927 that country consumed 3,000,000 tons out of the total world's production of 5,000,000 tons, and of this amount Canada contributed 1,628,000 tons. In addition Canada provided pulp wood and pulp sufficient to make an additional 2,000,000 tons of newsprint so that the fact remains that more than the required 3,000,000 tons of newsprint was provided from Canada either as paper or as the raw material from which newsprint could be made.

Should the time ever come (as it no doubt will) when the people of China, India, and Russia develop the news devouring appetite of the Americans, the demand for newsprint will tax the maximum production of the remaining forests on the world's surface. If these peoples possessed the reading habits of the Americans, Canadian forests in sup-

plying the demand would be exhausted in four or five years.

On comparing the relative value of newsprint, pulp, and pulpwood exported from Canada as shown below, one is impressed by the potential loss entailed in having pulp and pulpwood shipped out of



Value of Pulp and Paper manufactured in Canada, 1928.

the country. If all of the pulp and pulpwood now exported were to be manufactured into newsprint, the value of this industry to Canada would be increased threefold. Instead of producing $250,000,000 annually, the annual income from this source would be $750,000,000.

There are several reasons for this manufacturing condition. Foreign interests were the first to appreciate the value of our pulpwood, and with canny

forethought in providing wood for the mills across the border, secured, by purchase and lease, enormous areas of spruce covered land in Ontario and Quebec. It is difficult, even if desirable, to disturb the rights of vested interests. The farmers, settlers and small contractors in Ontario and Quebec are also strongly opposed to the placing of an embargo on the exportation of pulpwood. They are receiving $6.00 to $8.00 a cord for pulpwood — more if peeled—and do not look with favor on any measure calculated to put restrictions upon the market. The cutting off of the supply of raw material to many mills situated in a very friendly, neighboring country would no doubt cause much hardship amongst the workmen employed there, and a feeling of resentment, not confined to them alone, would be engendered against Canada. Another reason for proceeding slowly in this matter lies in the fact that all of the sulphur required for making sulphite pulp comes from Louisiana and Texas. Were an embargo placed on the export of pulp and pulpwood it might result in a retaliatory embargo on the exportation of sulphur to Canada. This is not, however, a likely possibility since sulphur can be obtained from sulphide reduction plants, and the consequence of such an embargo would be the recovery of sulphur from the smoke stacks of Canadian smelters, a source of sulphur much utilized in Europe but hardly at all in this country.

The uncertainty connected with the continuance of the export of pulp and pulpwood to the United

States, is discouraging the investment of much new capital in mills across the border, and stimulating its investment in Canada. Most of the new pulp and paper mills are being erected in the Dominion. Moreover the increase in the size of paper machines is making it more and more difficult for the small machines to compete with the recently erected new ones, and as practically all of these large machines are being put into Canadian mills, it is probably only a matter of time before this great, economic loss to Canada will automatically rectify itself.

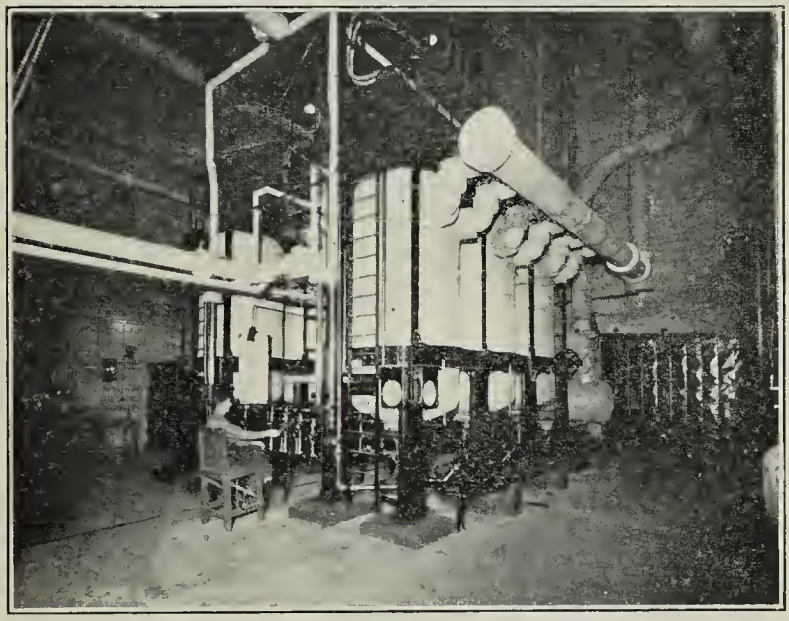
Leases are no longer given for the cutting of pulpwood on Crown lands for export. The wood cut on such lands must be made into newsprint in Canadian mills.

THE VALUE OF THE INDUSTRY TO CANADA

In 1928 the total cash value of the pulp and paper making operations to Canada amounted to about $250,000,000. This does not include the value of this industry to other industries supplying materials for the erection of mills, the operation of the chemical processes, the cutting and transportation of the wood, and many other activities connected with paper-making. Sulphur, limestone, soda ash, alum, clay, whiting, sizing, casein, dyes and colors to the value of over $2,000,000 were used by the paper mills in Canada in 1926, and over $3,500,000 of other supplies not readily listed.

Enormous quantities of water are required for the pulp and paper making operations. This re-

quires pumps, engines, piping, and men to operate them. Power for operating the mills is usually provided from hydro electric plants, and these require the building of enormous dams and the installation of expensive electrical equipment. The dams



Kaelin electric boilers installed at Pine Falls, Manitoba. These boilers provide all the steam and hot water required for the pulp and paper-making processes of the mill.

require large quantities of cement, sand, gravel, and stone, employing large numbers of men, not only in their erection, but also in the building of the power plants. A large staff of electrical and hydraulic engineers is required in the continuous operation of the power plant. Many of the pulp and paper-making processes require large quantities of hot

Timber Camp.

Hauling Pulp Wood by Tractors.

water and in Canada much of the heat is supplied from electric boilers, the designing and manufacturing of which has reached a high state of efficiency in this country.

Seasonal Employment

The cutting, hauling and all the other operations connected with securing pulpwood, except river-driving and booming, are almost entirely carried out in the winter season. The labor for these operations can be secured from the adjacent agricultural areas. Farming in Canada is largely a seasonal occupation employing many men during the summer, and releasing them after the harvest is secured. This excess labor is absorbed in the woods during the winter, and is accompanied by the employment of thousands of farm horses, otherwise eating their heads off in the stable. Fire patrol and timber cruising require the employment of men during the summer season. Many of these are recruited from the student body of our Canadian colleges and universities, who are offered congenial and healthful employment during the long summer vacation. The pulp and paper industry has largely solved the seasonal unemployment problem for all but the prairie provinces, and has in a very large measure removed the burden from the large urban centres, of supporting a winter army of unemployed.

Foreign Exchange

The value of the Canadian dollar in foreign exchange is based upon the relation of exports to imports. The rate of exchange is largely determined by the ratio of these two in the trade relations of Canada with each individual country. Thus our dollar is practically at par with the American dollar, which means that our imports from the United States approximate in value our exports to the same country, and as a consequence all trade relationships are on a parity in respect to money values. A Canadian dollar will pay for an American dollar's worth of goods. This equality with the United States has largely been attained through the favorable trade balance secured by our sales of newsprint and pulp to that country. Were it not for these sales our purchases from the United States would far exceed our sales to them, and the trade value of our dollar would drop. In other words, it would take more than a dollar in Canadian money to pay for a dollar's worth of American goods. The development of the pulp and paper industry in Canada has been the largest single contributor to the exports upon which our favorable trade relations with the United States are based.

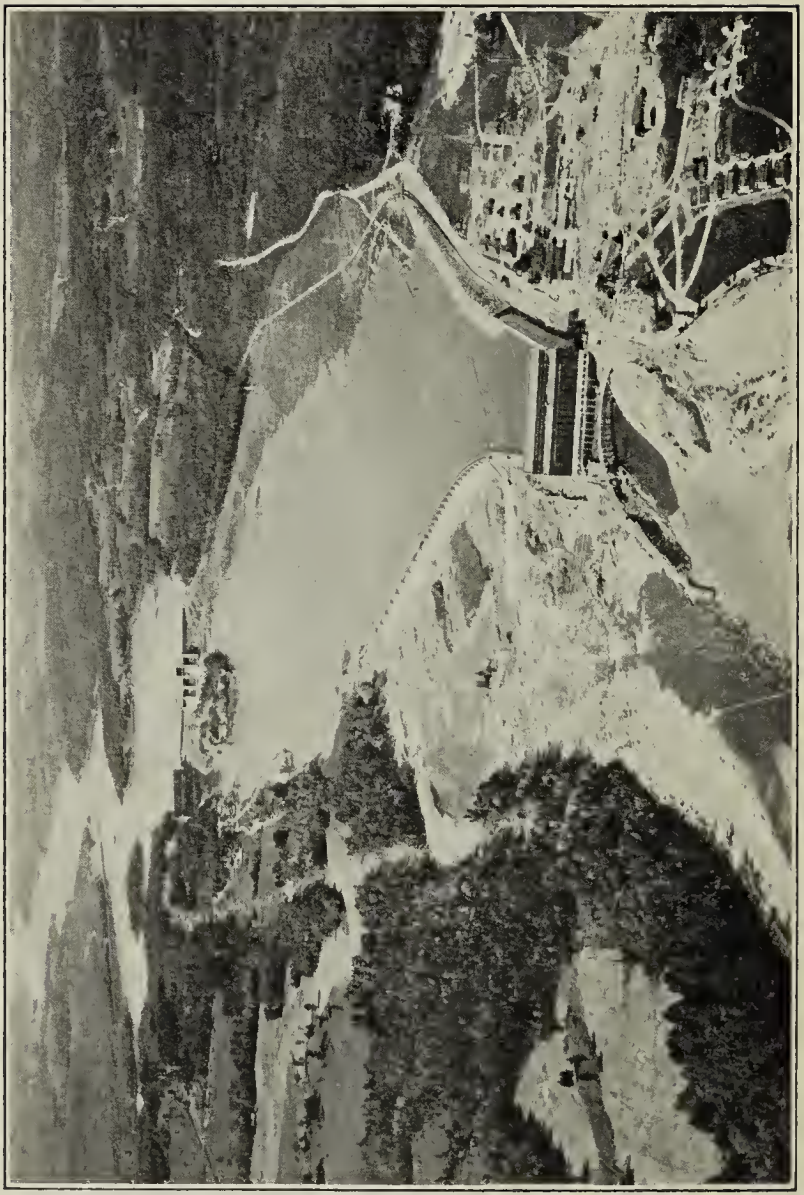
Capital Invested and Men Employed

The capital necessary to begin operating a pulp and paper-making mill is relatively large. Timber limits must be bought or rented, and water rights

on the lakes, rivers and streams of the timbered area secured. A dam and power plant may be required, the mill must be built, and all the expensive machinery installed. Timber camps must be established and a large supply of wood must be cut and brought to the mill, and a market secured for the product. There is no possible source of income until the mill begins to turn out paper. The capital invested in the pulp and paper industry in Canada, including lands, buildings, machinery, materials and stocks in 1927 was about $580,000,000.

During the same year 32,876 men were employed in the industry earning an average wage of $1,400 per man per year. The mills operated on an average of 254 days full time, 12 days part time and 39 days idle. The eight-hour day was in force with fifty-six per cent. of the workers.

The entire amount of foreign capital invested in Canada is about $5,300,000,000, of which huge sum $3,100,000,000 has come from the United States. The capital invested in the pulp and paper industry in Canada is about $525,000,000, and $400,000,000 is United States capital. This does not mean that the industry is operated for the people of the United States but does reflect the fact that there is a definite relationship between the capital invested, and the consumption of pulp and paper. The United States imports almost 90 per cent. of the pulp and newsprint manufactured in Canada, and has provided 76 per cent. of the capital necessary to bring about its production. Canada did not have the capital neces-



"Farmers" Hydro Plant, Gatineau River.

sary to develop this industry and, since the Great War, could not secure it from Great Britain.

Most American enterprises in Canada have been Canadianized. They employ Canadians to operate the properties and buy Canadian goods wherever possible. When the stock of a company operating in Canada is offered for sale, a portion of the issue is taken up in Canada, so that all available Canadian capital may be invested in her own industries.

Pulp and Paper Companies in Canada

The largest pulp and paper company operating in Canada is the International, the largest paper company in the world. In 1921 they took over the Riordon Company's extensive pulp interests, and since then have developed several of their properties, the most important development occurring on the Gatineau River, Quebec. This company has already developed 560,000 horse power of hydro-electric energy at three different locations on this river. They are now erecting a dam which will form the third largest artificial storage reservoir in the world. Much of this power is already sold to the provincially operated Hydro-Electric Power Commission of Ontario. The Canadian International Paper Company at present operate three mills, one near the city of Ottawa on the Ottawa River with a capacity of 600 tons of newsprint per day, another at Three Rivers producing 700 tons, and the third, the Kipawa, on the Upper Ottawa River, at Temiskaming, Quebec,

with a capacity of over 400 tons of newsprint per day. The International requires about 1,000,000 cords of wood each year and to guarantee this continuous supply of pulpwood, it controls over 18,000,000 acres of forest land.

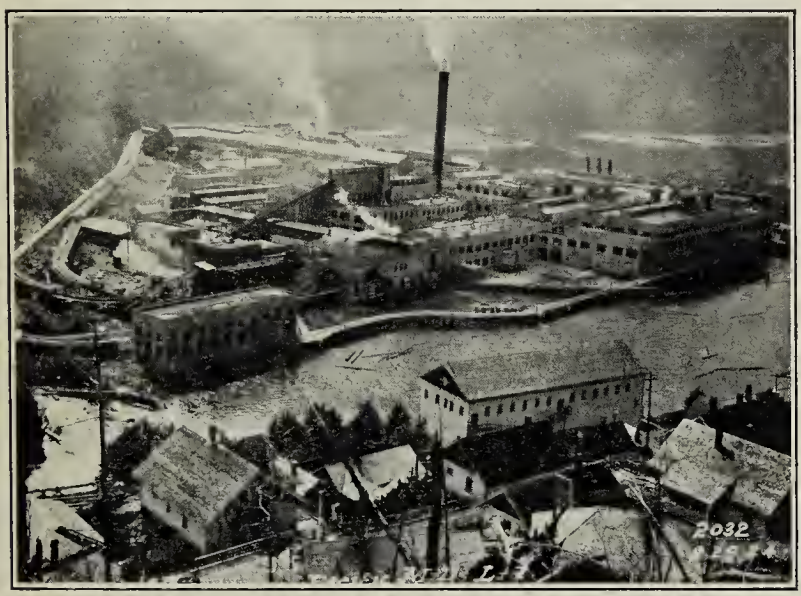
The Abitibi Power and Paper Company, with headquarters at Iroquois Falls, Ontario, own and operate ten pulp and paper mills, the combined output of which surpasses that of any other one company operating in Canada. This company has mills in Ontario at Iroquois Falls, Smooth Rock Falls, Fort William, Sault Ste. Marie, Espanola and Sturgeon Falls. In Quebec it operates mills at Beaupre and Murray Bay, and in Manitoba it owns and operates the mill at Pine Falls. The total production per day of the mills of this company is: groundwood pulp, 1840 tons; sulphite pulp, 635 tons; bleached pulp, 200 tons; newsprint, 2100 tons, and board pulp, 65 tons.

Another large company operating in Canada is the Spruce Falls Power and Paper Company, with a mill at Kapuskasing, Ontario, producing 550 tons of newsprint per day. The New York Times, which has a half interest in this mill, takes all of the paper made by it.

The Minnesota and Ontario Paper Company operate three mills in Canada, one at Fort Francis on the Rainy River, known as the Fort Francis Paper Mills, Limited, another at Kenora operating under the name of the Kenora Paper Company, and a third at Fort William, the Great Lakes Paper Com-

pany. The total daily output of these mills is at present over 800 tons.

The two largest mills operating on the Pacific Coast are the Powell River Company, Limited, at Powell River, and the Pacific Mills Ltd., at Ocean Falls. These two mills have a capacity of 700 tons



The Pacific Mills, Ocean Falls, B.C.

of newsprint per day. The product is sold to the large newspapers on the Pacific Coast and to New Zealand and Australia.

Two large pulp and paper companies operate in the Lake St. John-Saguenay River section of the Province of Quebec. The Price Brothers Company have recently established several large pulp and paper mills in this well wooded district, and the

Quebec Pulp and Paper Mills Limited are operating mills on the waters tributary to Lake St. John. The Kenogami mill of Price Brothers is one of the most modern pulp and paper mills in Canada. The mills in the Lake St. John district obtain their power from the wonderful hydro-electric development on the head waters of the Saguenay River. The Aluminum Company of Canada have harnessed the water power of this river at an expenditure of over $100,000,000, and from a development of about 1,400,000

Canadian Pulp and Paper Research Institute, University Ave., Montreal, containing experimental Paper Mill Laboratories, and Executive Offices of the Pulp and Paper Association.

Courtesy Westman Press.

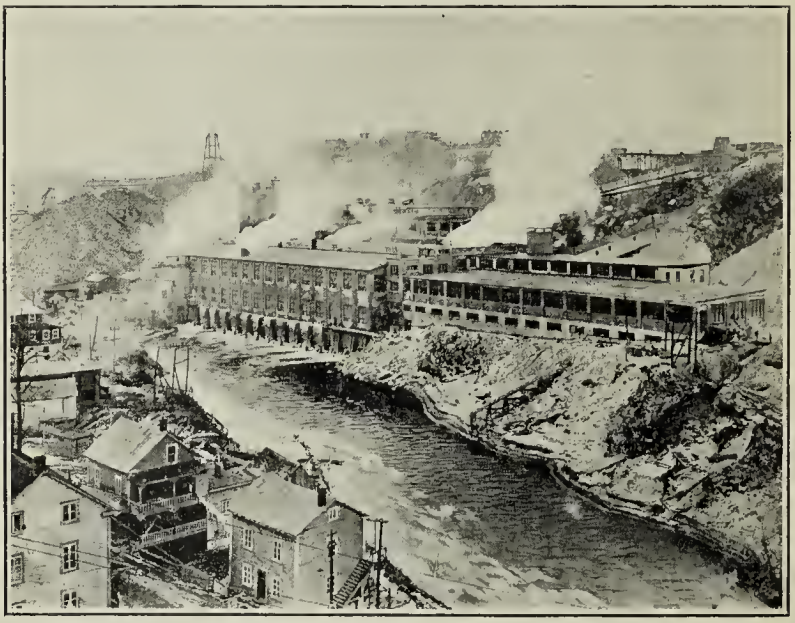
horse-power are distributing power to the local pulp and paper mills, the aluminum plant at Arvida and to industrial centres including the City of Quebec.

Other large mills manufacturing pulp and paper are the Wyagamack Pulp and Paper Co. Ltd., Three Rivers, Quebec, The Anglo-Canadian Pulp and Paper Mills Limited. Quebec City, the Laurentide Company at Grand Mére, Quebec, and the St. Maurice Valley Corporation at Shawinigan Falls, and Three Rivers. The Mattagami Pulp and Paper Company operate a large mill at Smooth Rock Falls, and the Bathurst Co. Ltd, at Bathurst, N.B. Many smaller mills are scattered throughout Ontario and Quebec some making both pulp and paper, some only pulp, and others only paper. The smallest paper mills are engaged in making book and writing paper, wrapping paper, tissue paper, building paper, paper boards, and fibre boards.

Pulp and Paper Research in Canada

The Canadian Pulp and Paper Association was founded as a trade association in 1913, and with 90 per cent. of the operating mills as members it is a truly representative body. This organization in co-operation with the Division of Pulp and Paper, Forest Products Laboratories of Canada, a federal government institution, is conducting investigations of fundamental importance to the pulp and paper industry. A laboratory at Montreal connected with McGill University has been built at a cost of over $300,000.00, and accommodation for

over 50 research students has been provided. A small pulp and paper mill has been erected, so that practical problems of the paper industry can be studied. The principal work of this laboratory is the study of the chemistry of wood and of cellulose



Power House, Pulp and Paper Mill and woodstack, St. Maurice Valley Corporation, Shawinigan Falls, Quebec. Note the huge pile of barked, spruce pulp wood in the upper left corner.

in particular. The establishing of this laboratory well illustrates the dependence of an industry upon scientific control and the necessity of co-operating with men of science in solving the problems that arise in the every day processes upon which the continued successful operation of the industry de-

pends. This is the only laboratory of its kind in Canada, and so many are the research problems already presented to it for investigation that only the most important ones are being studied.

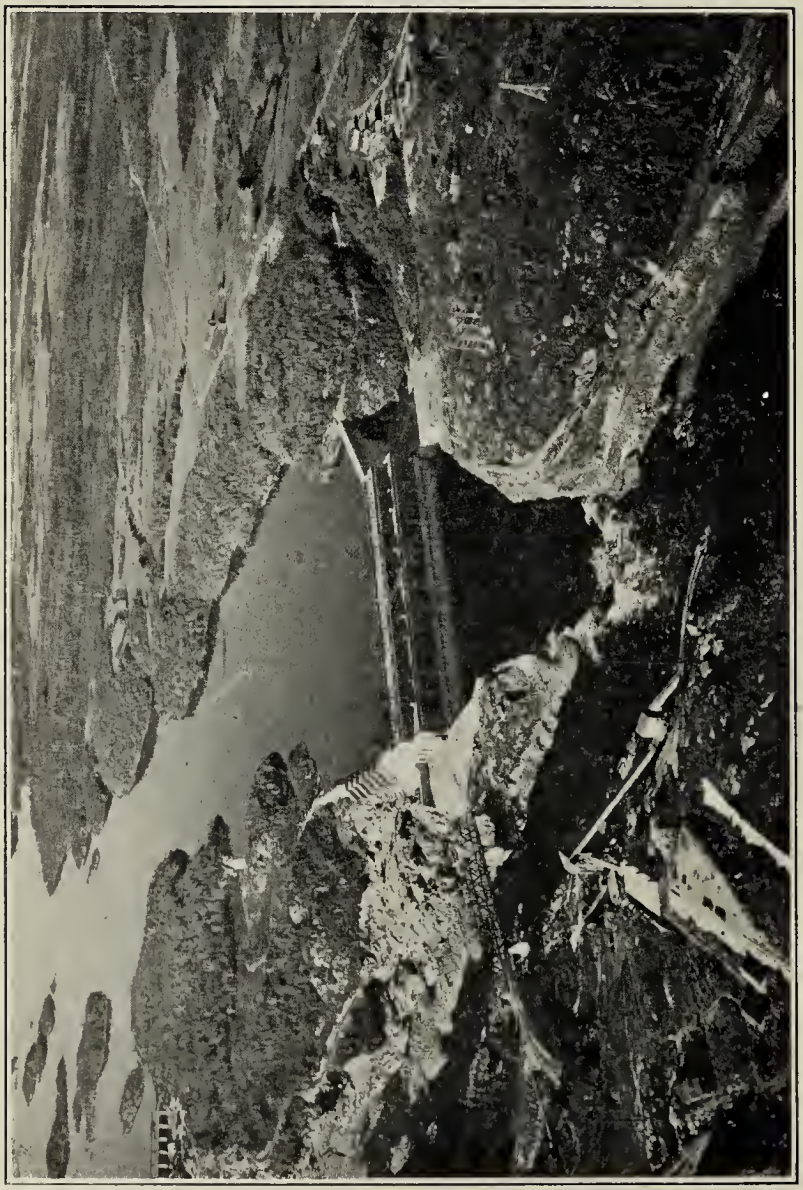
Some research connected with local pulp and paper mill problems is done in the chemical laboratory of certain individual mills, but only a few of these laboratories have the necessary equipment for the efficient performance of this work.

Graduate students in chemistry are finding employment in the laboratories of the pulp and paper mills and in the research laboratory of the Pulp and Paper Association at Montreal. The Forest Products Laboratories at Ottawa employ a number of chemists working on problems connected with the development of processes whereby forest products may be made more valuable in Canadian Industry.

Water Power in the Pulp and Paper Industry

The intimate relationship existing between water power development and the pulp and paper industry has already been referred to in this book. Ninety per cent. of the energy requirements of the pulp and paper mills in Canada is supplied by water power and this represents about thirty per cent. of the total water power developed in Canada.

Pulp and paper mills run continuously day and night; so can the water power turbines, and without additional cost. This offers the most economical application for water power since the cost of operation is very low as compared with that of coal,



Water Power Development of the Aluminum Company of Canada at Arvida on the Saguenay River, Que. Much of the Power generated is used by the Pulp and Paper Mills of the Lake St. John District.

oil, or gas-fired power plants. As a consequence of this 24 hour a day requirement, the paper industry secures very low-priced power from the water power companies. Moreover the use of electric steam generators whereby off-peak power may be used for producing steam for pulp cooking, drying and heating, has provided additional economies in the operation of the pulp and paper mills. Off-peak or surplus power is available during the hours of the day and night when other industries are closed down.

Water power plants need not be erected close to the pulp and paper mills for electric power can be transmitted long distances by overhead wires. The water power plant is erected at the best point for securing the maximum power development and the pulp and paper mill is erected on a site selected from the point of view of operation and transportation. Where it is possible to erect the power plant and mill on the same site the pulp and paper machines may be operated directly from the hydraulic power, but where the power and mill sites are apart, then the water power must first be converted into electric power and the machines are then operated from dynamos. Machines operating from electric power run with more uniform speed and produce a better product than those operating from hydraulic power.

Practically all of the pulpwood areas now being worked in Canada are provided with hydro-electric power. This relatively cheap source of power

makes it possible for pulp and paper mills to operate more economically than where steam power is required. The export of pulpwood and pulp to the United States is diminishing and the export of newsprint is increasing. New paper-making machines are being installed in the mills in Canada, while practically no new ones are being erected in the mills in the United States. The reason lies in the fact that cheap hydro-electric power is more available for the mills in Canada.

AVAILABLE PULP WOOD AND WATER POWER OF CANADA

Province	Estimated Pulp Wood Resources Million Cords	Available Water Power at Ordinary Minimum Flow H. P.
British Columbia	290	1,921,000
Alberta	252	390,000
Saskatchewan	142	542,000
Manitoba	67	3,309,000
Ontario	200	5,330,000
Quebec	330	8,459,000
New Brunswick	35	87,000
Nova Scotia	28	20,800

MARKETING CONDITIONS

The wide-spread distribution and the number of companies have made the continuous operation of all of the pulp and paper mills in Canada somewhat difficult. The cost of manufacture and of marketing the product is not uniform and consequently mills with high operating and marketing costs find

it difficult to compete with the more favored companies, especially when an over production of pulp and paper occurs. A tendency towards combination and towards production-limitation agreements amongst the paper companies has been noted during the last few years. The object of these combinations and agreements is to prevent over production and stabilize the price and market. Whether such will be successful remains to be seen.

PULP AND PAPER PRODUCTION IN CANADA

The following tabular information has been secured from "The Pulp and Paper Industry" of the Dominion Bureau of Statistics, and the report of the Forest Products Branch of the Dominion Bureau of Statistics for 1927:

PULP PRODUCTION IN CANADA 1909-1927

Year:	Mechanical Pulp: Tons	Chemical Pulp: Tons	Total Tons
1909	325,609	119,799	445,408
1913	600,216	254,408	854,624
1917	923,731	540,423	1,464,154
1921	931,560	612,467	1,544,027
1925	1,621,917	1,084,992	2,706,909
1926	3,229,791	1,251,178	4,480,969
1927	1,922,124	1,278,572	3,200,696

PULP WOOD PRODUCTION IN CANADA 1909-1927

	Used in Canadian Pulp Mills Cords:	Exported to other countries as pulpwood Cords:	Total Cords:
1909	622,129	935,624	1,557,753
1913	1,109,034	1,035,030	2,144,064
1917	2,104,334	1,017,845	3,122,179
1921	2,180,578	1,092,553	3,273,131
1925	3,668,959	1,423,502	5,092,461
1926	4,229,567	1,391,738	5,621,305
1927	4,387,687	1,541,769	5,929,496

PULP AND PAPER MILLS IN CANADA 1927

	Pulp Mills:	Pulp and Paper Mills:	Paper Mills:
Nova Scotia	7	—	—
New Brunswick	4	1	1
Quebec	16	20	14
Ontario	12	17	15
Manitoba	—	1	—
British Columbia	3	3	1

KINDS OF WOOD USED IN PULP PRODUCTION IN CANADA 1927

	Cords:
Spruce	3,141,318
Balsam Fir	877,504
Hemlock	187,951
Jack Pine	140,355
Poplar	11,866
All Others	28,693

VALUE OF PULP PRODUCTION IN CANADA 1927

Groundwood pulp	$ 44,174,811
Sulphite fibre (bleached)	21,087,792
Sulphite fibre (unbleached)	33,803,631
Sulphate (Kraft) and Soda fibre	14,277,579
Screenings	1,098,737
Total	$114,442,550

VALUE OF PAPER PRODUCED IN CANADA 1927

Newsprint	$ 132,286,729
Book and Writing Paper	12,916,469
Wrapping Paper	9,607,828
Paper Boards	8,985,788
Other kinds of Paper	4,433,926
Other products	214,808
Total	$ 168,445,548

CANADIAN EXPORTS 1927

Agricultural and Vegetable Products	$546,293,422
Wood and Paper	280,959,319
Animal Products	164,711,508
Non-ferrous Metals	87,057,150
Iron and its products	67,831,374
Non Metalic minerals	26,932,012
Chemical products	17,266,252
Fibres and Textiles	10,926,510
Miscellaneous	16,359,226
Total Exports	$1,238,782,004

CANADIAN EXPORTS 1928

Agricultural and Vegetable Products	$651,078,560
Wood and Paper	289,125,744
Animal Products	163,457,632
Non-ferrous Metals	103,288,613
Iron and its products	70,665,677
Non Metalic minerals	26,583,611
Chemical products	18,356,645
Fibres and Textiles	9,731,623
Miscellaneous	17,463,298
Total Exports	$1,374,130,197

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